THE JOURNAL
Volume 19, No. 2
pp. 29-62

CERAMIC ABSTRACTS
Volume 15, No. 2
pp. 51-78

AMERICAN CERAMIC SOCIETY

FEBRUARY • 1936

MONTHLY PUBLICATIONS DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES

Vol. 19, No. 1, Journal, pp. 1-48 — JOURNAL OF THE AMERICAN CERAMIC SOCIETY, JANUARY, 1936 — Vol. 15, No. 1, Ceramic Abstracts, pp. 1-50

TABLE OF CONTENTS

Vol. 19 February, 1936 No. 2

THE JOURNAL OF THE AMERICAN CERAMIC SOCIETY

The Use of Penetrating Radiations in the Measurement of the Porosity of Refractory Brick..... 29
By J. B. Austin

Loading Device for Load-Test Furnace..... 36
By J. L. Carruthers

A New Method for Studying the Flow Characteristics of Glasses and Slags at Elevated Temperatures..... 39
By E. P. Barrett and James A. Taylor

Stress Release in Glass. A Phenomenon Involving Viscosity as a Variable with Time..... 45
By H. R. Lillie

Effect of Mill Practice and Mill Additions on Opacity of Enamels..... 55
By G. L. Bryant and F. R. Porter

Effect of Clays on the Opacity of White Enamel for Sheet Steel..... 59
By R. R. Danielson

CERAMIC ABSTRACTS

Vol. 15 No. 2

Abrasives..... 51
Art and Archeology..... 52
Cements..... 54
Enamel..... 55
Glass..... 57
Structural Clay Products..... 62
Refractories..... 63
Terra Cotta..... 66
Whiteware..... 67
Equipment and Apparatus..... 67
Kilns, Furnaces, Fuels, and Combustion..... 70
Geology..... 71
Chemistry and Physics..... 73
General..... 77

The American Ceramic Society Trustees and Officers for 1935–1936

President: J. M. McKinley, North American Refractories Co., Cleveland, Ohio
Vice-President: Francis C. Flint, Hazel-Atlas Glass Co., Washington, Pa.
Treasurer: H. B. Henderson, H. B. Henderson Co., New Brighton, Pa.
Secretary-Editor: Ross C. Purdy, 2525 North High St., Columbus, Ohio
Past-President: W. Keith McAfee, Universal Sanitary Mfg. Co., New Castle, Pa.
Past-President: John C. Hostetter, Corning Glass Works, Corning, N. Y.

Trustees from the Industrial Divisions

Art: Frederick H. Rhead, Homer Laughlin China Co., Newell, W. Va.
Enamel: W. C. Lindemann, Lindemann & Hoverson Co., Milwaukee, Wis.
Glass: J. T. Littleton, Corning Glass Works, Corning, N. Y.
Materials and Equipment: Victor V. Kelsey, Consolidated Feldspar Corp., Trenton, N. J.
Refractories: R. B. Sosman, United States Steel Corp., Kearny, N. J.
Structural Clay Products: R. B. Keplinger, Metropolitan Paving Brick Co., Canton, Ohio
Terra Cotta: R. L. Clare, Federal Seaboard Terra Cotta Corp., Woodbridge, N. J.
White Wares: Perry D. Helser, General Ceramics Co., New York, N. Y.

Industrial Divisions

Art
Chairman: L. E. Barringer, General Electric Co., Schenectady, N. Y.
Secretary: C. M. Harder, 800 S. Halsted St., Chicago, Ill.

Enamel
Chairman: R. M. King, Ohio State University, Columbus, Ohio
Secretary: B. J. Sweo, National Bureau of Standards, Washington, D. C.

Glass
Chairman: U. E. Bowes, Toledo, Ohio.
Secretary: S. R. Scholes, N. Y. State College of Ceramics, Alfred, N. Y.

Materials and Equipment
Chairman: C. H. Peddrick, Jr., United Feldspar Corp., 10 E. 40th St., New York, N. Y.
Secretary: J. E. Eagle, Vitro Mfg. Co., Pittsburgh, Pa.

Refractories
Chairman: R. B. Sosman, United States Steel Corp., Kearny, N. J.
Secretary: H. M. Kraner, Bethlehem Steel Co., Bethlehem, Pa.

Structural Clay Products
Chairman: A. F. Greaves-Walker, Univ. of North Carolina, Raleigh, N. C.
Secretary: G. H. Duncombe, 150 East Frambes Ave., Columbus, Ohio

Terra Cotta
Chairman: J. L. Carruthers, Ohio State University, Columbus, Ohio.
Secretary: H. E. Davis, Federal Seaboard Terra Cotta Corp., Woodbridge, N. J.

White Wares
Chairman: T. A. Klinefelter, National Bureau of Standards, Washington, D. C.
Secretary: S. J. McDowell, General Ceramics Co., Keasbey, N. J.

Local Sections

Baltimore-Washington
Chairman: Roy A. Blunt, Buck Glass Co., Baltimore, Md.
Secretary: G. H. Spencer-Strong, Porcelain Enamel & Mfg. Co., Baltimore, Md.

California
Chairman: F. A. McCann, Pacific Clay Products Co., Los Angeles, Calif.
Secretary: T. S. Curtis, Industrial Research Laboratories, Huntington Park, Calif.

Central Ohio
Secretary: C. A. Austin, Battelle Memorial Institute, Columbus, Ohio

Chicago
President: G. G. Hanson, Consolidated Feldspar Corp., Chicago, Ill.
Secretary: H. V. Kaeppel, Industrial Publications, Inc., 59 E. Van Buren St., Chicago, Ill.

Michigan-Northwestern Ohio
Chairman: P. W. Dager, Champion Spark Plug Co., Detroit, Mich.
Secretary: Macon C. Trabue, Mt. Clemens Pottery Co., Mt. Clemens, Mich.

Pacific-Northwest
President: H. R. Kreitzer, Columbia Brick Co., Portland, Ore.
Secretary: Hewitt Wilson, Univ. of Washington, Seattle, Wash.

Pittsburgh
Chairman: R. E. Birch, Harbison-Walker Refractories Co., Pittsburgh, Pa.
Secretary: Earl C. Petrie, Mellon Institute, Pittsburgh, Pa.

St. Louis
Chairman: J. W. Wright, Owens-Illinois Glass Co., Alton, Ill.
Secretary: Burnett Purcell, Northwestern Terra Cotta Co., St. Louis, Mo.

Committee on Publications
Chairman: Louis Navias, General Electric Co., Schenectady, N. Y.
M. F. Beecher, Norton Co., Worcester, Mass.
L. J. Trostel, General Refractories Co., Baltimore, Md.
R. M. King, Ohio State University, Columbus, Ohio

Editorial and Advertising Offices:
The American Ceramic Society, 2525 North High St., Columbus, Ohio

Publication Office: 20th and Northampton Sts., Easton, Pa.

Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published monthly.
Subscription fifteen dollars ($15.00) a year. Single numbers $1.50
(Foreign and Canadian postage, 50c additional on subscriptions)
(Copyright 1936, American Ceramic Society, Inc.)

THE USE OF PENETRATING RADIATIONS IN THE MEASUREMENT OF THE POROSITY OF REFRACTORY BRICK*

By J. B. Austin

Abstract

The possibility of using the absorption of X-rays or γ-rays in a refractory brick as a measure of porosity has been tested experimentally for both kinds of radiation. It is found that the method is entirely practical in either case and when the necessary apparatus is set up it should yield results, with much less effort, better than those now obtained by the displacement method. Gamma-rays from radium appear to have some advantages over X-rays.

I. Introduction

The most satisfactory methods at present available for measuring the porosity of refractory materials depend upon filling the void space within a measured bulk volume of the material with a fluid of known specific volume, such as water or air. The principle is simple, yet, in spite of a considerable amount of work directed toward the improvement of these methods, the measurement of porosity remains a tedious operation yielding results which are in many cases still somewhat uncertain. There is in consequence a genuine need of a rapid, simple, yet accurate method. It has become increasingly evident, however, that any real advance must come through the development of a new technique. One scheme which offers a reasonable prospect of success involves the absorption by the material under test of some penetrating radiation, such as X-rays or γ-rays. This absorption, which for a given composition is a function of the number of atoms in the path of the ray, should, under controlled conditions, be a direct measure of porosity. A series of preliminary experiments indicates that, with proper calibration, the method is entirely feasible, either with X-rays or γ-rays and that it can be applied to all the common refractory materials. Moreover, it appears likely that it can be developed into a continuous process permitting the nondestructive testing and control of a large number of samples. The initial cost of the equipment is relatively high but the upkeep should be small, particularly if γ-rays are used.

(1) Principle of the Method

A beam of X-rays or γ-rays passing through the sample under test suffers a loss in intensity because of the conversion of a portion of the radiant energy into other forms and because of scattering, as light is scattered in a fog. As a matter of convenience, no distinction is made between the several types of loss, and the whole weakening is frequently called absorption.

If the beam is monochromatic, that is, consists of but one wave-length, the intensity, I, of the beam after passing through a thickness, x, of the material is given by the relation

$$I = I_0 e^{-\mu x}, \qquad (1)$$

where I_0 is the initial intensity and μ is the "linear absorption coefficient" or the fractional decrease in intensity per unit length. If it is assumed[1] that the porosity is equal to the average percentage of void space in any given direction, we may substitute for x a value in terms of the porosity, p, expressed as a fractional part of the total thickness of the sample.

Thus, for a brick having a thickness of 2.5 inches we write

$$I = I_0 e^{-2.5\mu(1-p)}, \qquad (2)$$

where μ is the absorption coefficient per inch. If μ, which is constant for a given material and a given wave-length, is known, p can be calculated directly from the absorption; if μ is not known, the relative porosity of two samples can be calculated by combining the equations for the two, thus

$$\frac{(1 - P_1)}{(1 - P_2)} = \frac{\ln I_1/I_0}{\ln I_2/I_0}. \qquad (3)$$

Equation 2 also shows that I is an exponential function of p, so that if the measurements on a

* Scheduled for presentation at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 29–April 4, 1936 (Refractories Division). Received September 6, 1935.

[1] This assumption is admittedly an approximation but one which experience seems to indicate is a satisfactory one. See for example "An Experimental and Theoretical Investigation of Quantitative Microscopic Mineralogical Analysis," Ravitz and Steane, A.I.M.E. Contribution No. 76 (1935); also Johannsen, Manual of Petrographic Methods, p. 290 ff. McGraw-Hill Book Co., New York, 1918.

series of brick whose porosity has been determined by another method are plotted against p on semilogarithmic coördinates they should fall on a straight line.

There are, therefore, three ways in which the method can be applied. First, the absolute porosity can be calculated from the absorption coefficient of the material and from the observed loss in intensity of the beam after passing through the brick; second, the relative porosity of two bricks can be calculated from the absorption; third, a calibration curve based on the absorption of brick of known porosity can be constructed. Since data on μ for the common refractories are lacking and since the last method is the most direct and is the one most likely to be used in practice, it has been used almost entirely in this investigation.

It is important to note that the absorption is substantially independent of the molecular state of the material as long as the atomic constitution remains unchanged. For example, in a silica brick having a given number of SiO_2 molecules in the path of the beam, the mass absorption coefficient is the same whether the silica be present as quartz, cristobalite, or tridymite. On the other hand, since the several modifications have a different density, the space density of silica brick depends on the crystalline phases present; hence the amounts of each phase present must be known if an absolute and highly accurate value of porosity is to be obtained. For this reason, it appears that the accuracy of the method should be greater in determining the relative porosity of samples of essentially the same constitution than in the direct measurement of a sample of unknown composition. If, however, the highest accuracy is not desired, or if a large batch of samples of reasonably uniform constitution is to be examined, a direct determination of reasonable accuracy can be made.

II. Methods of Measuring Intensity of Beam

(1) Photographic Method

In some preliminary experiments, which were made by R. H. Aborn of this laboratory, an attempt was made to estimate the intensity of the beam from the time required to produce a given blackening on a photographic plate. The brick under examination was held with one 9- by $4^1/_2$-inch face against a circular aperture in the steel cylinder surrounding a molybdenum-target X-ray tube operated at 33 kilovolts so that the center of the brick was $6^1/_2$ inches from the target; the corresponding face on the other side was directly in front of an aluminum cassette containing the film and a rear intensifying screen. Under these conditions, the exposure required to give a negative of moderate density was 1.5 seconds for a bloated clay brick, 1 minute for a bloated silica brick, and 3 hours for a regular silica brick.

The time of exposure for the denser materials can be greatly decreased by the use of double intensifying screens or of a tungsten-target tube operated at higher voltages, but exposing the negative is but a small fraction of the total time required for the complete operation so that relatively little improvement would result from the use of "harder" radiation. In any case, the marked difference in texture on the photographs, arising from the difference in texture of the samples, is a handicap which is inherent in this method. The use of an integrating photometer would overcome this difficulty to a large extent but would complicate the procedure still more, since the processes of exposing, developing, and drying the plate must be carefully controlled, and the results would be little, if any, better than those obtained by present methods. The photographic method has, therefore, been discarded as impractical.

(2) Ionization Method

In this method the radiation, after passing through the sample, enters a chamber containing a gas, usually air, which it ionizes and thereby renders capable of conducting electricity. The amount of ionization is, within certain limits, directly proportional to the intensity of the beam entering the chamber, so that the intensity can be determined by measuring the ionization, either by the rate of discharge of an electroscope or by the current produced between two electrodes in the chamber (the "ionization current"). This method is direct and precise but has the disadvantage that special instruments are required, an objection which is, however, not serious since the necessary equipment is easily available commercially. In this investigation, ionization chambers operating on each of the principles mentioned have been used with success.

III. Measurements with Gamma-Rays

Since there are a large number of radioactive elements it is pertinent to examine the list to see which one is most suitable for the present purpose. In making the choice, several factors must be considered. (1) The element must, obviously, emit γ-rays; not all the active elements do this. (2) Since γ-rays have a definite spectral distribution, an element to be of use must emit radiation which is intense in the region of very short wave-lengths, for the penetrating power is inversely proportional to the cube of the wave-length. (3) The element must have a reasonably long half-life period; otherwise it disintegrates before it can be used. (4) The element must be relatively abundant and easily available.

NOTE: The half-life period is the time required for the disintegration of one-half of a given preparation and is a constant characteristic of each radioactive element.

Neglecting those which show the recently discovered phenomenon of "induced activity" and confining ourselves to the members of the three great radioactive families, there are 40 active elements known, of which only about a dozen emit γ-rays. In the actinium series, actinium C and actinium B both emit γ-rays, but in each case the wave-length is relatively long and the half-life period is only a few minutes so that neither suits the requirements. In the thorium series, mesothorium II and thorium C emit penetrating rays which are fairly intense, but these elements have a rather short half-life period, a few hours in the first case, a few minutes in the second, and are not easily obtainable. In the radium series there are two good prospects, namely, radium B and radium C, of which radium C emits the greater energy; in fact it radiates the largest amount emitted by any element. Both have a half-life period of only a few minutes, but they are descendants of radium itself (half-life 1590 years) through radon (half-life, 3.82 days) and are constantly being produced by these elements; hence, if a quantity of radium is sealed in a container so that no disintegration products can escape, the concentration of radon, radium B, and radium C increases until, after about a month, equilibrium between the several disintegration reactions is established and a preparation containing a constant concentration of radium C is obtained, thus providing a convenient and relatively intense source of "hard" γ-rays. Finally, such a preparation is commercially available at a price, which though relatively high, is not prohibitive. The cost of 30 milligrams of radium, which actual test shows is ample, is of the same order of magnitude as that of a suitable X-ray apparatus, and the radium does not deteriorate through use.

Through the courtesy of G. Failla of the Memorial Hospital, a few measurements have been made with a radium preparation such as the one just described, using an apparatus shown schematically in Fig. 1. The brick under test was placed between the radium, R (in this case 50 milligrams in a tiny brass tube), and the measuring chamber, MC, the wall of which served as one

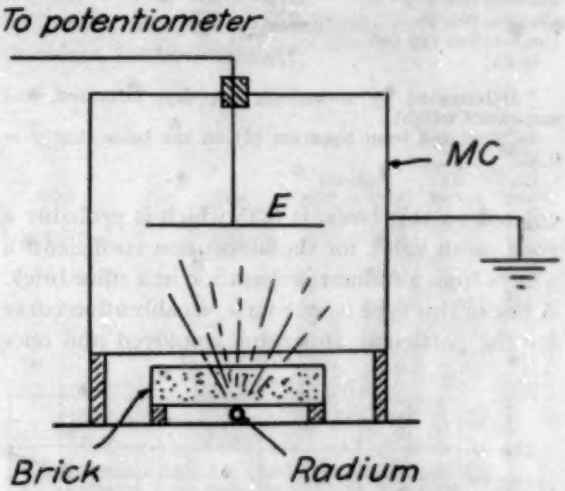

FIG. 1.—Schematic diagram of apparatus used in measuring the absorption of γ-rays in passing through a refractory brick.

electrode. The other electrode, E, was connected to a vacuum-tube potentiometer of the type designed by Dr. Failla[2] which measures the ionization current through the chamber. This instrument is described in detail in the reference cited but, for the benefit of those who are interested and to whom the original is not available, a brief description is given in an Appendix to this paper (p. 35).

The results obtained are given in Table I. Since the amount of scattered radiation reaching the chamber varies slightly with the position of the brick, a check measurement with the brick in a different position was made in several cases as indicated in Table I. Considering the simplicity of the apparatus used, the readings show satisfactory agreement.

[2] G. Failla, *Radiology*, 15, 437 (1930).

The data are also shown graphically in Fig. 2, which shows ionization current plotted on semi-logarithmic coördinates as a function of porosity. It is clear from the diagram that equation (2) can be applied to this case, and the value of μ, calculated on this basis, is 0.35 which is probably a good mean value for the absorption coefficient of γ-rays from a radium preparation in a silica brick. A line of this type is, of course, a calibration curve for the particular apparatus employed and once determined enables one to obtain the porosity of a silica brick directly from a measurement of the ionization current.

TABLE I

Sample	Porosity* (%)	Current in measuring chamber in electrostatic units (1E.S.U. = 3.335 × 10^{-10} amp.) 1st reading	Check	I/I_0 Observed	I/I_0 Calculated†
Silica No. 1	24	0.398		0.511	0.514
Silica No. 2	30	.422	0.421	.541	.542
Silica No. 3	32	.431	.433	.555	.551
Silica No. 4	53	.485		.623	.662
Chrome No. 1		.278	.284		
Chrome No. 2		.275	.273		
Unabsorbed ray (no brick)		.778			

* Determined by measuring the dry, saturated, and suspended weight.

† Calculated from equation (2) on the basis that $\mu = 0.35$.

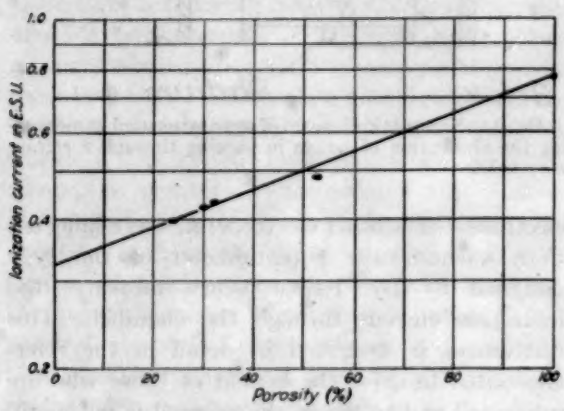

FIG. 2.—Diagram showing variation of ionization current with porosity of silica brick.

The values in Table I also demonstrate the range of application of the method, for silica is relatively transparent while chromite is relatively opaque to γ-rays, so that it should be possible to obtain satisfactory results with any of the common refractory materials.

In these measurements, the tube containing the radium (50 mg.) was placed 10 inches from the ionization chamber. If the preparation were moved closer, to 3 or 4 inches for example, 30 milligrams of radium would probably be ample.

One important factor to be considered in connection with the use of γ-rays is the danger to the operator. This hazard, which has been somewhat exaggerated by some of the popularizers of science, is, nevertheless, real. For sources of equal intensity, the danger is much greater with γ-rays than with X-rays because of the greater penetrating power of the former. But this very property of greater penetration makes it possible to use radioactive preparations of an intensity far less than is commonly necessary with X-rays, so that in practice the difference between proper shielding in the two cases is not great. On the other hand, one must admit the existence of a psychological factor, for the tiny radium tube looks quite harmless and a careless operator might be tempted to pick it up with his bare hands, in which case the intensity at the fingers is very high.

Shielding is most easily accomplished by keeping the radium in a lead-lined container, the thickness of the lead depending on the intensity of the preparation. The thickness of lead required to absorb *all* the γ-radiation is, however, so great that its use would be a serious drawback, but evidence is now available[3] to show that complete absorption is not necessary because there is a certain value of intensity below which the human body is not injured even by continuous exposure. To quote Dr. Failla, "In the case of 40 milligrams of radium one could surround it with $4^1/_4$ inches of lead and sit on the container eight hours a day for several years without being injured. The same degree of safety is obtained at a distance of three feet by surrounding the 40 milligrams of radium with only $^3/_4$ inch of lead." It is, therefore, possible to obtain satisfactory protection in much the same way as for X-rays. It should also be noted that with radium the process can easily be made automatic and no operator need be present for any length of time.

IV. Results with X-Rays

Unless otherwise stated the source of the radiation was a molybdenum-target tube operated at

[3] Personal communication from Dr. Failla.

33 kilovolts and 18 milliamperes. This equipment, which was designed for the examination of metals, is not the most desirable for use with relatively thick sections of refractory materials, but proved, nevertheless, to be adequate for a quantitative study of the proposed method. The ionization chamber employed with this tube was a small portable one, designed for physicians, in which the intensity of ionization was indicated by the rate of discharge of an electroscope. The usual procedure was to charge the electroscope, expose it to the beam emerging from the brick under test, and determine the rate of discharge in terms of divisions on an arbitrary scale by means of a stopwatch.

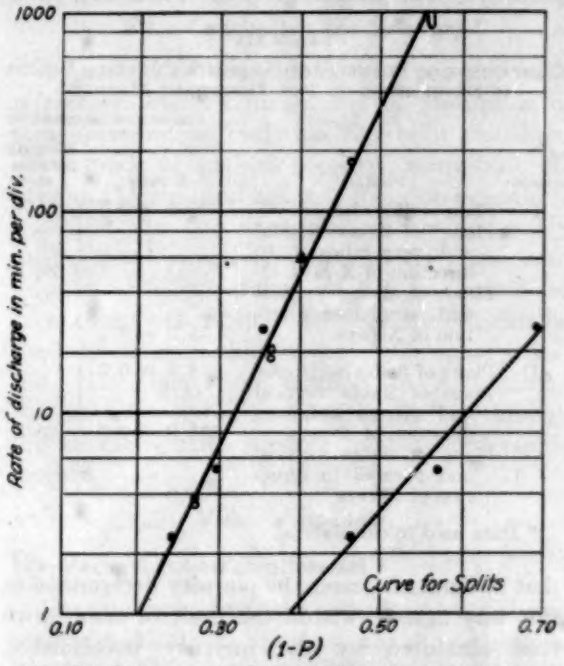

FIG. 3.—Diagram showing variation of rate of discharge of electroscope with $(1 - p)$ for silica brick. Circles are points for standard size brick; black disks for splits; the triangle for a commercial lightweight brick.

In studying this method, we were fortunate in having a series of standard-size silica brick ranging in porosity from 33 to 73%.[4] The brick in this set were alike in every respect except the total void space and so enabled us to determine the effect of porosity alone.

A set of three splits made by sawing brick of the three lowest porosities was also available. As a further check on the applicability of the method, measurements were made on a commercial lightweight silica brick selected at random from a lot supplied by the manufacturer.

The results are given in Table II and are shown graphically in Fig. 3, in which the time of discharge of the electroscope is plotted against $(1-p)$, the percentage of the total thickness occupied by silica. This quantity was chosen instead of p itself because it permits an easier comparison between the values for a split and a standard-size brick. Thus, the amount of material in a split having a given value of $(1-p)$ is the same as that in a standard size brick with a value of $(1-p)$ half as great; hence in the figure, a point for a split can be compared directly with those for the $2^1/_2$-inch brick by dividing its abscissa by two. A single calibration curve suffices, therefore, for both sizes.

TABLE II

Brick	Size	Porosity (p)*	Porosity ($1-p$)	Rate of discharge in min./div. Observed	Rate of discharge in min./div. Calculated†
Silica No. 1	Standard	73.7	26.3	3.6	3.9
				3.9	
" No. 2	"	64.0	36.0	20.5	26.5
				17.5	
" No. 3	"	54.1	45.9	176	197
" No. 4	"	43.3	56.7	(850)	
" No. 5	"	33.0	67.0		
" No. 3	Split	54.1	45.9	2.5	2.0
" No. 4	"	43.3	56.7	5.3	5.8
" No. 5	"	33.0	67.0	27	16
Lightweight	Standard	60.0	40.0	60	60

* Determined from bulk and true specific gravity.

† Calculated from equation (2) in the form $T_0/T = e^{-2.5\mu(1-p)}$, where T is the time of discharge in minutes per division, on the basis that $\mu = 8$ and $T_0 = 0.02$.

The data for the rate of discharge in the table have been corrected for the leakage from the electroscope when the chamber is not exposed to X-rays. For the densest of the $2^1/_2$-inch brick, the absorption was so great that the rate of discharge was of the order of magnitude of the rate of leakage so that the results are somewhat uncertain. Thus no satisfactory measurement could be made on No. 5, while the value for 4 is only an approximation, which fact has been indicated in the table by inclosing it in parentheses. In plotting the data, the size of the symbol marking the location of a given point has been made to indicate its order of accuracy.

The curves indicate that equation (2) provides an adequate representation of the data and thus yields the form of the calibration curve. In fact, a curve of this type is itself a calibration curve corresponding to a value of μ of approximately 8.

[4] Obtained through the courtesy of the Harbison Walker Refractories Co.

It should be noted that the adjusted points for the splits lie reasonably well on the curve for the thicker brick. The point for the lightweight silica brick also agrees well with the points for the graded series, indicating that reasonable accuracy would be attained in applying the method to most silica brick.

The apparatus used is clearly not the best for testing the denser brick, and the use of a different type of tube operated at a higher voltage would give better results. This is shown by some measurements made by R. H. Aborn with a tungsten-target tube.[5] Using an ionization chamber of the kind just described in the experiments, he found that the discharge time for a $2^1/_2$-inch silica brick (porosity approximately 30%) was 31 seconds with the tube operating at 145 kilovolts and 4 milliamperes, and 162 seconds with 80 kilovolts and 6 milliamperes. With this increased rate of discharge, the troublesome correction due to leakage and the consequent uncertainty of the result are avoided.

V. Directional Effects

For most of the common refractories, which are substantially isotropic, the possibility of directional effects is negligible. On the other hand, there are a few refractory materials such as clay-graphite crucible bodies, in which there is an oriented structure, and for these there is a chance that the porosity calculated from absorption measured in a single direction may not be characteristic of the body as a whole. In order to permit a test of this question in at least one case, H. E. White, who originally called the attention of the author to it, kindly supplied several samples of crucible bodies whose porosity had been measured by means of a mercury porosimeter. Since the samples were in the form of cubes approximately 1 inch on edge, the absorption of X-rays was conveniently measured in three mutually perpendicular directions. The results could not be compared directly, however, because the blocks were not true cubes and the thickness of the absorbing material was different for each direction. It was necessary, therefore, to reduce the data to some common basis, which unfortunately, can only be done if the absorption coefficient, μ, is known. In this case, it is possible to estimate, on the basis of the composition of the blocks, that the value of μ should be between 2 and 4, but a much more accurate value is necessary for the correction. It was decided, therefore, to calculate μ from the observed absorption in one direction of one of the blocks, using the measured thickness and the porosity determined by the mercury porosimeter. The value so obtained, namely 3.06, was then used to calculate the porosity in the other two directions of the same block and in all three directions of another block of slightly greater porosity. The results, given in Table III, show

TABLE III

COMPARISON OF POROSITY OF GRAPHITE CRUCIBLE BODIES AS DETERMINED BY TWO DIFFERENT METHODS

		Porosity as measured by	
Sample	Position	X-rays	Mercury porosimeter
I	Plane of flakes horizontal	36.2 ± 0.3	
	Plane* of flakes vertical and perpendicular to direction of X-rays		36.3
	Plane of flakes vertical and parallel to direction of X-rays	35.3 ± 0.3	
II	Plane of flakes horizontal	38.5 ± 0.3	
	Plane of flakes vertical and perpendicular to direction of X-rays	38.3 ± 0.3	38.3
	Plane of flakes vertical and parallel to direction of X-rays	38.8 ± 0.3	

* Data used to calculate μ.

that in 3 out of 5 cases the porosity determined in this way agreed, within the limit of error, with that measured by the mercury porosimeter. In the two exceptions the differences are not large and, although both occurred with the blocks in the same position, the differences are not systematic, that is, the porosity as calculated from the absorption is in one case higher, and in the other lower than the value obtained with the mercury porosimeter. The differences are, therefore, not considered significant and it is concluded that the orientation of the graphite produces no appreciable change in the absorption of X-rays. If there is any effect it is less than our error of measurement.

VI. Comparison of Results Using Gamma-Rays and X-Rays

The proposed method is entirely feasible, and with proper apparatus the determination is simple and quickly and easily made with either

[5] Made available through the courtesy of the Adlanco Industrial Products Co.

type of radiation. The equipment for using γ-rays is compact, rugged, and can be made portable, while the X-ray apparatus is more bulky. Satisfactory protection of the operator can easily be obtained with either kind of radiation. The γ-rays have a greater penetrating power, which gives them a somewhat wider field of application, and have the advantage that the wave-length and intensity of the radiation is constant over a long period of time without any attention from the operator. On the whole, the γ-rays seem to be better adapted to this purpose than the X-rays.

VII. Conclusions and Summary

A method of determining the porosity of a refractory brick by measuring the absorption of some penetrating radiation has been tested on silica brick of known porosity, using both X-rays and γ-rays, and has been found to be entirely feasible. The test is simple, quickly and easily made, nondestructive, and can be made continuous. The apparatus must be calibrated for each composition but once standardized can be used for different thicknesses of the same material. The ionization method of determining the intensity of the beam after passing through the sample is much superior to the photographic method.

VIII. Appendix

The Vacuum-Tube Potentiometer

The essential part of the circuit, which is shown diagrammatically in Fig. 4*a*, is the three-electrode vacuum tube, *T*. In this tube the filament, *F*, which consists of a metal wire heated by passing a current from battery *A* through it, serves as a source of electrons. Opposite the filament is a metal plate, *P*, which is kept at a positive potential with respect to the filament by the battery, *B*, and between the filament and plate there is placed a metal-gauze grid, *G*. Electrons liberated by the filament are attracted toward the plate and, since the intervening grid has large interstices, most of the electrons can pass through and reach the plate, thus producing a thermionic "plate" current which is measured by the milliammeter, *Ma*. If, however, the grid, which is insulated from the other elements of the tube, is charged negatively it repels the electrons emitted by the filament and prevents some, or all, of them from reaching the plate. The plate current is, therefore, very sensitive to changes in the potential of the grid.

If now the electrode of the ionization chamber, *MC*, is connected to the grid, and the chamber is then exposed to an ionizing radiation, an ionization current flows through the chamber to the grid, thereby changing its potential and altering the plate current in the vacuum tube. The sensitivity of a potentiometer is greatest when it is used as a "null" instrument, that is, when the

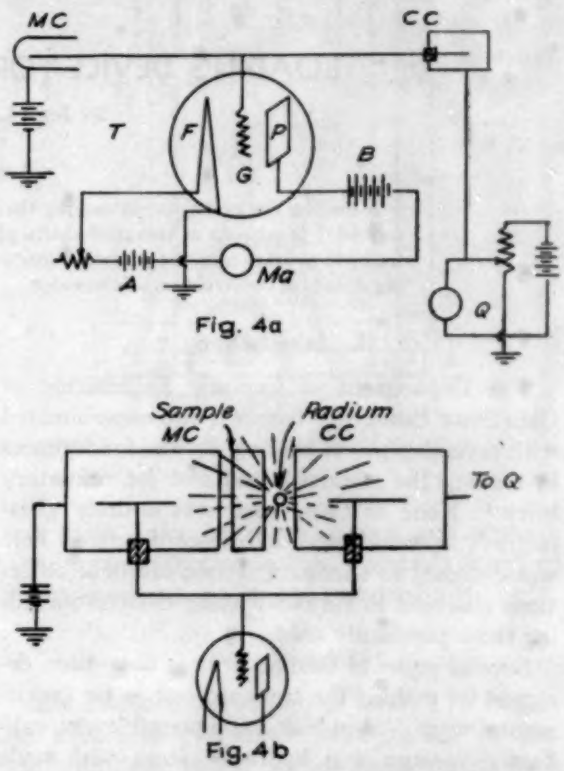

FIG. 4.—Schematic wiring diagram of Failla potentiometer.

effect of the unknown current is exactly balanced by a second current opposite in direction, so that the pointer of the milliammeter returns to its normal or "zero" position; hence, an arrangement is provided for producing a known compensating current. This is done by the use of a compensating chamber, *CC*, which is an air-tight ionization chamber containing a known amount of radium salt. Since the activity of this preparation does not vary, the current through the chamber can be controlled by varying the voltage across *CC* by means of the resistance, *Q*, so that with this set up the current from *MC* can be exactly balanced by a known current from *CC*.

The apparatus as described involves the use of two sources of ionizing radiation, but if the radiation used to test the brick comes from radium, the use of a second preparation can be avoided by placing the compensation chamber in a fixed position with respect to the active material (see Fig. 4*b*). One preparation of radium serves, therefore, for both measuring and compensating chambers.

Acknowledgment

It is a pleasure to acknowledge the help received from R. H. Aborn, G. Failla, and R. H. H. Pierce, Jr., who cooperated in making the measurements. We are also indebted to the Harbison-Walker Refractories Company for the series of silica brick and the Adlanco Industrial Products Company for the loan of valuable apparatus.

RESEARCH LABORATORY
UNITED STATES STEEL CORPORATION
KEARNY, NEW JERSEY

LOADING DEVICE FOR LOAD-TEST FURNACE*

BY JOHN L. CARRUTHERS

ABSTRACT

A loading device for use in making the standard load test on refractory brick is described. It consists of two steel shafts plus added weights, mounted in a simple steel frame to provide true direct vertical loads on the two test samples. Illustrations showing details of construction are included.

I. Introduction

The Department of Ceramic Engineering at Ohio State University has used and experimented with several types of loading devices for furnaces in making the standard load test for refractory brick.[1] None of those used was entirely satisfactory; consequently the device described here was designed to eliminate certain faults or objections observed in various loading devices, including those previously used.

Several styles of loading devices have been designed for making the standard test or for experimental work. Simple and compound levers, calibrated springs, and hydraulic jacks with scale beams have been used to produce the required load. In some laboratories, especially in Europe, direct loading of a small test piece cut from the sample has been used. Since the load required for a standard brick (ordinarily not over 300 pounds) is not great, it was believed that a loading device could be designed which would obtain the actual load required without the use of any of the mechanical devices previously noted and would be easy to handle. Experience to date has proved that the design described here is satisfactory and meets all specifications desired in such a device.

II. Specifications

The following specifications were set up as a basis for a satisfactory design:

(1) The load must be applied vertically to meet the requirements of the standard test.
(2) The load must be the same at all times during the test.
(3) There must be no possibility of an eccentric load on the sample at any time due to the action of the loading device.
(4) The device must be simple to operate and must not require attention during the test.
(5) There must be no need for the adjustment of counter-weights or calibration of parts from time to time.
(6) The device should be strong, rigid, and relatively inexpensive.

III. Design

Figures 1 and 2 show the construction of the loading device. It consists of a simple braced steel frame in which are mounted two steel shafts, one for each test brick. A solid collar is securely fastened to each shaft with a bolt. A steel plate rests on this collar and serves as a base for the cast-iron weights which are added to obtain the necessary load.

The shafts are held in vertical alignment by means of steel cross-plates fastened to the frame.

---

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Refractories Division). Received August 7, 1935.

[1] "Standard Method of Test for Refractory Materials under Load at High Temperatures (C16-20)," *A.S.T.M. Standards* [Part II], p. 179 (1933).

The shaft holes in the plates are bored to provide for a sliding fit on the shaft. The bolt holes in the plates and at the end of the supporting angles are drilled extra large to permit adjustment of the plates to secure true vertical alignment.

Several tests were made to determine whether the friction between the plates and the shaft would reduce the amount of the applied load. The amount of friction was negligible. In order to eliminate any possible error due to friction on the shaft or binding with the plates, the arrangement shown in Fig. 3 has been designed as optional equipment. Vertical alignment in either direction is obtained by adjustment of the guide rollers.

Ample clearance between the lower frame angles and the furnace top has been provided so that

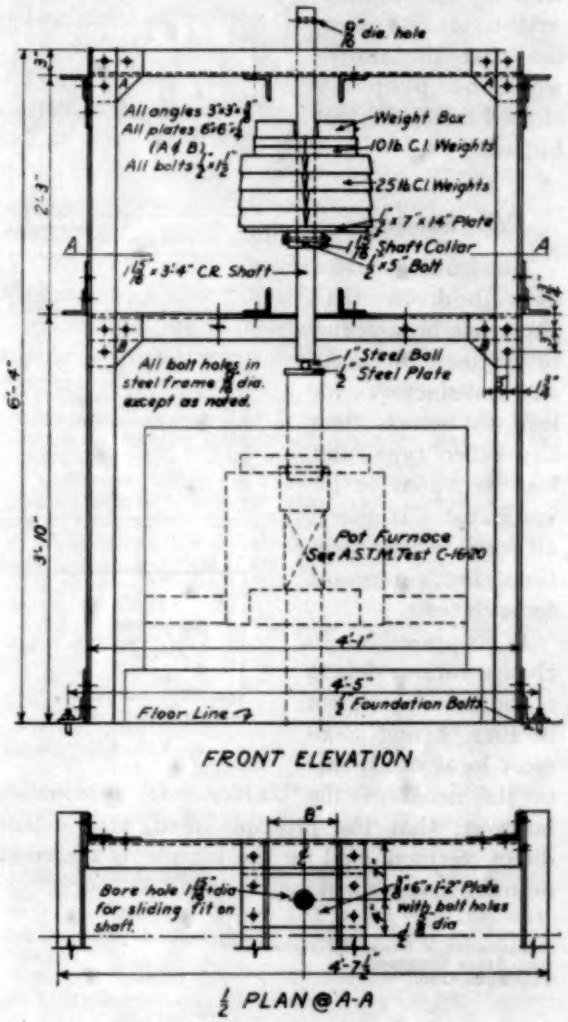

FIG. 1.

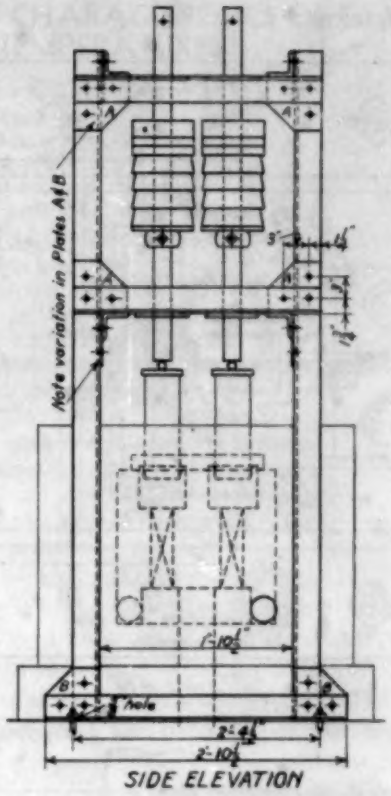

FIG. 2.

test brick may be easily placed and aligned. The furnace indicated in Figs. 1 and 2 is described in the specifications for the standard test.[1]

IV. Weights

The standard test requires a load of 25 pounds per square inch of cross-section of the sample, which amounts to 281 pounds and 4 ounces for a standard 9-inch straight brick ($2\frac{1}{2}$ by $4\frac{1}{2}$ by 9 inches). The applied load consists of (*a*) refractory shapes resting on the sample and extending through the furnace cover, (*b*) a shaft with collar and plate, (*c*) large cast-iron weights symmetrically arranged around the shaft, and (*d*) two galvanized-iron boxes loaded with lead shot as required to make up the exact load. The weight of the refractory shapes must be determined for each furnace. The estimated weight of the shaft, collar, and plate shown in Figs. 1 and 2 is 50 pounds, but the exact weights should be determined by weighing. The total load that may be applied to test pieces ranges from 60 to 300 pounds or more.

The shape and dimensions of the 10- and 25-

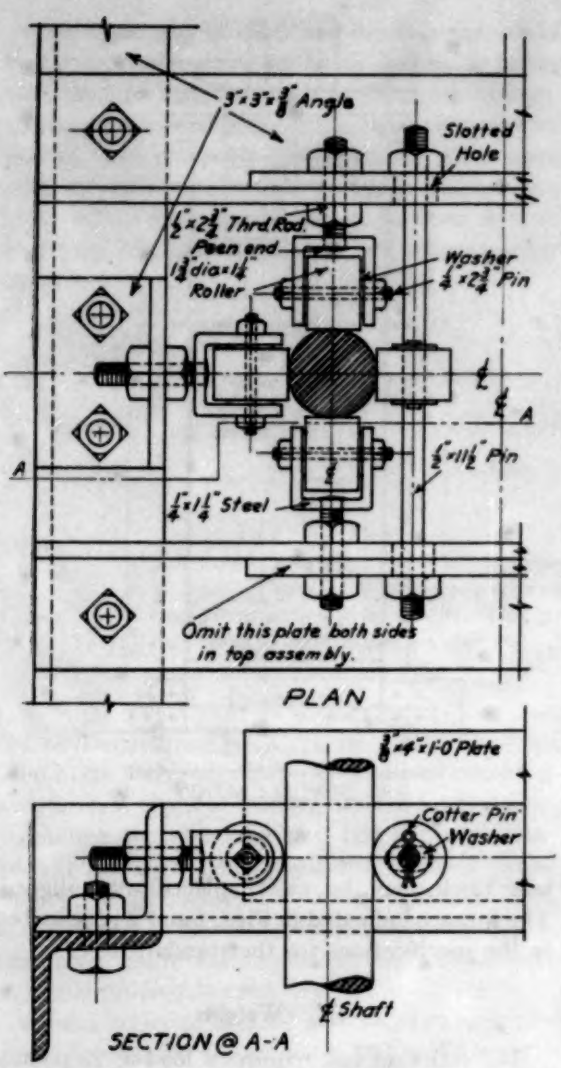

FIG. 3.

pound cast-iron weights and the weight boxes are shown in Fig. 4. The dimensions of the weights are for cast iron at 0.26 pound per cubic inch. Any overweight or underweight of the cast-iron pieces can be corrected by grinding or plugging with lead. The sides of the 25-pound weights are beveled to provide ease of handling during loading and unloading of the machine. Eight 25-pound and four 10-pound weights are required for ordinary routine testing.

The device as shown requires that each shaft be loaded and unloaded at the beginning and end of each test. The labor involved in handling approximately 500 pounds of cast-iron weights is not strenuous since the unit weights are not heavy. A chain hoist or block and tackle may be provided to lift the loaded shaft if desired. A light block and tackle or a lever should be used for raising or lowering the unloaded shaft when placing or removing the test brick.

V. Miscellaneous

The steel framework, not including the shaft and weight assembly, as shown in Figs. 1 and 2 is estimated to weigh 525 pounds. The frame could be made of lighter or heavier steel, but the size used in the design will provide a rugged and substantial frame.

Only standard steel shapes and equipment have been used in this design. All pieces can be fabricated in the average machine shop and erected by a millwright. It is essential that the framework be properly aligned with the pot furnace.

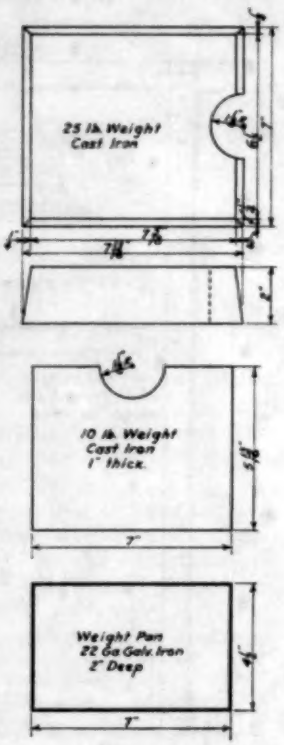

FIG. 4.

VI. Summary

The loading device described in this paper has been found to be more accurate and satisfactory for load-test work than any other type that has been used or investigated. It meets all desired specifications for equipment for such tests.

It is possible to change various details of the assembly shown in Figs. 1 and 2 to meet local conditions or the needs of the builder. It is believed, however, that the principle used, *viz.*, a true direct vertical load on the sample, is the most desirable one for making the load test.

DEPARTMENT OF CERAMIC ENGINEERING
OHIO STATE UNIVERSITY
COLUMBUS, OHIO

A NEW METHOD FOR STUDYING THE FLOW CHARACTERISTICS OF GLASSES AND SLAGS AT ELEVATED TEMPERATURES*

By Elliott P. Barrett† and James A. Taylor‡

Abstract

Viscosities and surface tensions of glasses and slags are properties of great practical importance but they are frequently difficult to measure. The methods which yield results in absolute units are time-consuming and are not applicable to a study of the behavior of partly devitrified silicate melts.

This paper describes an empirical method for estimating not only the relative fluidity of glasses and slags but also for determining the lowest temperature at which crystallization from a previously chilled vitreous slag will occur on reheating, the approximate rate at which devitrification proceeds at various temperatures, and the range of temperature within which devitrification is complete enough to prevent flow of the slag under its own weight.

By an extension of the method to mixtures of crystalline substances, the behavior of such mixtures upon heating may be studied advantageously. By a further extension of the technique, the temperature at which the solid-liquid interfacial tension becomes low enough to permit wetting of a solid by a glass or slag may be determined. The applicability of these techniques to vitreous enameling problems is indicated.

I. Introduction

The viscosity and surface tension of glasses and slags at elevated temperatures are properties of great practical importance. A number of methods for measuring these properties, some empirical and some calculated to yield results in absolute units, have been reported by Greiner,[1] Arndt,[2] Veseley,[3] Staley,[4] Doelter,[5] Williams and Cox,[6] Feild,[7] Twyman,[8] Washburn, Shelton, and Libman,[9] Stott, Irvine, and Turner,[10] Littleton,[11] Lillie,[12] McCaffery,[13] and Wadleigh.[14] In practice, it is frequently unnecessary to know more than the relative magnitudes of these properties for different samples of similar materials in order to understand, predict, or control the behavior of the materials under some particular set of conditions. What is really required is a technique which is rapid, cheap, facile, and reproducible so that relative values may readily be obtained. It is the purpose of this paper to describe a procedure which has been applied to slags of widely differing composition and properties to yield useful practical information.

II. Outline of the Procedure

The general procedure is as follows: The material to be studied is brought to a temperature such that it is completely molten and held at this temperature until escape of gas from the molten mass ceases. With liquids of high viscosity, it is necessary to superheat well above the liquidus temperature in order to complete this "fining" operation in a reasonable length of time. The liquid is then chill cast into billets, $^1/_2$ inch in diameter and approximately $^1/_2$ inch high, by pouring into steel molds of the appropriate dimensions. One of these billets

* Received September 9, 1935.

† Research Associate and ‡Research Assistant in Fuel Technology, Mineral Industries Experiment Station, The Pennsylvania State College, State College, Pa.

[1] E. Greiner, "Über die Abhängigkeit der Viskosität in Silikatschmelzen von ihrer chemischen Zusammensetzung," Dissertation, Univ. of Jena, 1907.

[2] Kurt Arndt, "Die Messung der Zähigkeit," *Z. chem. Apparatenkunde*, **3**, 549 (1908).

[3] V. Veseley, "Über die Viskosität des Glases," *Sprechsaal*, **44**, 441 (1911).

[4] H. F. Staley, "The Viscosity of Borate Glasses," *Orig. Com. 8th Intern. Cong. of Applied Chem.*, **5**, 127 (1912).

[5] C. Doelter, "Über die Viskosität der Silikatschmelzen," *Chem. Ztg.*, **36**, 36 (1912).

[6] A. E. Williams and S. F. Cox, "Notes on Barium Glasses," *Trans. Amer. Ceram. Soc.*, **18**, 336 (1916).

[7] A. L. Feild, "A Method for Measuring the Viscosity of Blast-Furnace Slag at High Temperatures," *U. S. Bur. Mines Tech. Paper*, No. 157, 1916.

[8] F. Twyman, "The Annealing of Glass," *Jour. Soc. Glass Tech.*, **1**, 61 (1917).

[9] E. W. Washburn, G. R. Shelton, E. E. Libman, *Univ. of Ill. Eng. Expt. Sta. Bull.*, No. 140, 1924.

[10] V. H. Stott, E. Irvine, and D. Turner, "Viscosity Measurements with Glass," *Proc. Roy. Soc.*, **108**, 154 (1925).

[11] J. T. Littleton, Jr., "A Method for Measuring the Softening Temperature of Glasses," *Jour. Amer. Ceram. Soc.*, **10** [4] 259 (1927).

[12] H. R. Lillie, "The Measurement of Absolute Viscosity by the Use of Concentric Cylinders," *Jour. Amer. Ceram. Soc.*, **12** [8] 505 (1929).

[13] R. S. McCaffery and coworkers, "Viscosity of Blast-Furnace Slags," *Amer. Inst. Mining Met. Engrs., Tech. Publ.*, No. 383, 1931; *Trans. A. I. M. M. E.*, **100**, 64–140 (1932).

[14] W. H. Wadleigh, "The Viscosity of Optical Glass," *Bur. Stand. Jour. Research*, **11**, 65 (1933); R.P. 577.

is stood upon a refractory base and placed in a gas-fired muffle furnace of special design.[15] The important feature of this furnace is that an object placed within the muffle is always viewed against a background somewhat lower in temperature than the muffle itself. Consequently the billet is readily visible even at the highest temperatures, which may be of the order of 2800 to 3000°F. A cathetometer telescope is focused on the billet so that accurate measurement of its height is possible at all times, and the furnace temperature is raised uniformly at a rate of 15 Fahrenheit degrees per minute until the temperature is reached at which the billet has flowed down to 20% of its initial height.

This outline shows that the procedure yields data which exhibit the height of the test piece as a function of temperature or, since the rate of heating is constant, of time. Before discussing the practical importance of these data, it is desirable to call attention to certain details of technique which are essential to the general applicability of the procedure.

III. Details of Technique

Because it is necessary to heat the slag to temperatures of the order of 2800 to 3000°F before casting the billets, the problem of reaction between slag and container is very serious. Slags which do not contain oxides of iron can be melted in graphite, but many slags of industrial importance contain considerable amounts of iron and for these graphite can not be used because of the rapid reduction of iron to the metallic state. Even platinum does not wear well in contact with molten slags containing considerable amounts of FeO and Fe_2O_3, especially if a somewhat reducing atmosphere is used. Moreover, it is desirable to use a cheap container which can be discarded rather than to clean a platinum one, especially when a large number of measurements are to be made. To avoid reaction with the container, the apparatus shown in Fig. 1(*A*) was constructed. The figure is a schematic representation of a gas-fired pot furnace. The flame enters the pot tangentially through the burner port, *B*, and escapes tangentially through the exhaust port, *E*. The top of the pot is closed by the plug through which passes the observation port, *O*, which is about 3/8 inch in diameter.

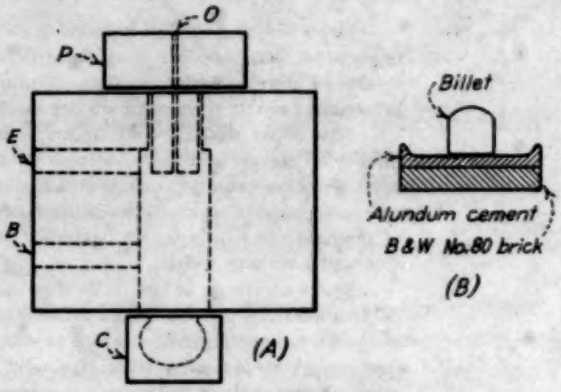

FIG. 1.—(*A*) radiation furnace for melting slags; (*B*) billet mounted for measurement (B & W No. 80 brick is now known as Babcock and Wilcox No. K-30).

Through *O*, an optical pyrometer is sighted into the crucible, *C*, which contains the slag. This crucible is made from Babcock and Wilcox No. K-30 insulating brick (formerly called No. 80) and its interior is lined with Alundum cement.

From the figure it will be seen that the walls of the crucible are rather thin. Consequently there exists a rather steep thermal gradient from the slag in the crucible to the outer wall of the crucible. The slag is heated primarily by radiation from the bottom of the plug, *P*, and from the inner wall of the pot. The Alundum cement does not react appreciably with the slag even at elevated temperatures, but the cement is rather porous. Therefore, some of the molten slag flows through the cement until it reaches a region too low in temperature to permit further flow. It will be seen, however, that, although some of the sample is wasted in this way, there can occur no contamination of the billets which are cast by pouring from the crucible into molds.

If the billets are left in the molds after casting they will, of course, crack from thermal shock. Therefore, they are quickly transferred from the molds to a container of Sil-O-Cel. In making a measurement, the billet is stood upon a base made from a slab of Babcock and Wilcox No. K-30 insulating brick, 1/4 inch thick, covered on its upper surface with a layer of

[15] Elliott P. Barrett, "A Furnace for the Measurement of Coal-Ash Softening Temperature." Paper presented at the 38th Annual Meeting of the A. S. T. M., June, 1935.

Alundum cement $^1/_8$ inch thick as shown in Fig. 1(*B*).

IV. Flow Curves and Their Practical Significance

It is convenient to express the results obtained by plotting the height of the billet against temperature. Because it is not possible to cast all billets so as to give them exactly the same height, it is desirable to express the height at any temperature as a percentage of the initial height so that results obtained with different billets may be directly compared. Repeated measurements with billets of the same composition but different initial heights indicate that the height may vary from 0.5 to 0.75 inch without any appreciable difference in the rate of flow at any given temperature, provided that the percentage of the initial height is plotted against the temperature. The graphs obtained in this way have been designated as "flow curves."

Figure 2 shows four typical flow curves. A glance at the figure suffices to indicate how clearly this type of measurement shows important differences in properties between various slags. The most obvious feature of these curves is that their slopes are primarily functions of viscosity. It is true that surface tension is also an important factor but, as will be shown later, it is usually possible to determine

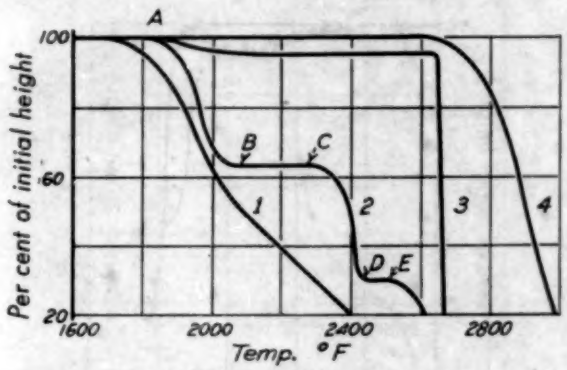

FIG. 2.—Typical flow curves.

from the curves themselves when the surface tension is great enough to be of importance in forming an estimate of the ease with which the slag will flow under some particular set of operating conditions. The curves, however, yield more information about the slags than a practical measure of their fluidity. To illustrate the information which may be derived from these curves, curve 2 of Fig. 2 will be discussed in detail.

It will be recalled that the billets are made by heating to a temperature well above the liquidus and then suddenly chilling by pouring into a steel mold at room temperature. Consequently the billets are completely vitreous. Referring now to curve 2 of Fig. 2, it will be seen that in the vicinity of 1800°F (point *A*) the glass becomes sufficiently fluid to deform under its own weight. As the temperature rises, the curve passes through a point of inflection and at point *B* flow has ceased. It is apparent that, while the temperature was changing from *A* to *B*, the glass was devitrifying and that when *B* was reached sufficient solid had crystallized from the melt to prevent further flow. On the other hand, the interval from *B* to *C* is a solution range and when the temperature corresponding to *C* is reached sufficient solid has redissolved for flow to begin again. The significance of the range from *D* to *E* can not be grasped from the flow curve alone, but observations of the shape into which a billet has flowed, when its flow curve exhibits this second flat range, show that it is due to the liquid having a surface tension great enough to hold it in a lenticular form. Consequently, the slag is unable to flow out over the plaque and the height remains constant until, with rising temperature, the surface tension becomes small enough to permit spreading to occur.

The foregoing discussion suffices for the simpler curves of Fig. 2 as well as for curve 2 itself. It does not cover a phenomenon which is of fairly frequent occurrence but which is not illustrated in Fig. 2. With some slags there is observed an increase in height over the initial height at temperatures between 1500° and 2000°F. This increase may be as great as 5 or even 10% and is not to be ascribed to thermal expansion which is of a lower order of magnitude. In those instances where it has been observed there has been no reason for ascribing it to a change in the crystalline form of a solid phase because, it will be recalled, we are not dealing with a crystalline solid at these temperatures but with an undercooled liquid. Close observations of billets which displayed this increase in height before devitrifying have shown that the phenomenon is to be ascribed

to high surface tension because the added height is produced by the rounding of the flat bottom of the billet into a segment of an ellipsoid.

It should, perhaps, be pointed out that in the case of a curve which shows only one break,

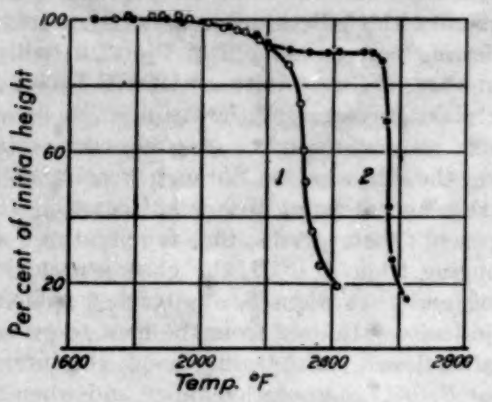

FIG. 3.—Viscosity is not the sole factor controlling rate of devitrification.

e.g., curve 4 of Fig. 2, devitrification probably occurs at too low a temperature to be observed and that it may occur while the glass is too viscous to flow appreciably. In this connection it seems worth while to point out that viscosity is not the sole factor determining the rate of devitrification at temperatures between the liquidus and that of the lowest eutectic in the system being studied. This is indicated by the curves of Fig. 3 which show the behavior of two slags of similar composition and of identical viscosity up to 2150°F, one of which devitrifies rapidly enough to prevent flow in the range from 2300 to 2500°F, while the other never devitrifies sufficiently to stop flowing.

From the foregoing data, it will be seen that this type of measurement provides a useful and rapid means for predicting the behavior of glasses and slags under various conditions after various thermal histories.

V. Reliability and Limitations of the Method

Curve 1 of Fig. 4 shows the reproducibility of the results. In the figure, the open and closed circles represent, respectively, the results of the first and second measurements on the slag. The dotted circles show the results obtained by remaking the batch and casting a new billet. The agreement between the first two measurements and the third shows clearly that the technique by which the billets are prepared achieves its objective of avoiding contamination of the slag by solution of the container in which it is melted.

It must be pointed out that the method does not yield results comparable with equilibrium viscosities of glasses because, as Lillie[12] has shown, many hours at a fixed temperature are required for silicate glasses to attain their true viscosities at that temperature. This consideration, however, does not detract from the practicality of the method for many purposes. It is quite possible to obtain results which are approximately comparable by maintaining the glass or slag at the temperature in which the observer is interested for sufficient time for equilibrium to be attained and then casting a billet. The billet can then be reheated cautiously to a high enough temperature to avoid breakage by thermal shock and then quickly inserted into a furnace held at the desired temperature and the rate of deformation with time be observed.

VI. Extension of the Method to the Study of Crystalline Substances

It is frequently desired to study the processes which accompany the melting of mixtures of finely divided solids. By making the same

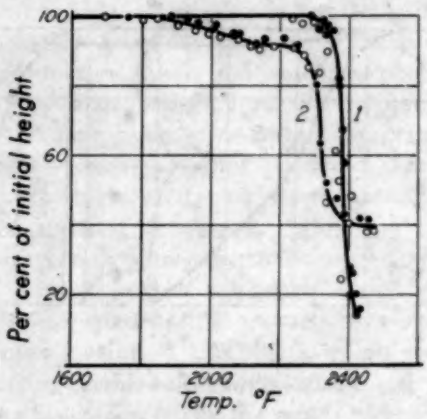

FIG. 4.—Reproducibility of results and comparisons of behavior of billets and briquets.

measurement on a pressed briquet of the same size and shape as the billets, useful information may be derived. A particular application of this technique would be to a study of the influ-

ence of pressure and fineness of grinding on the behavior of pyrometric cones and cones made from mineral mixtures for the purpose of determining pyrometric cone equivalents.

That the temperature at which flow of the glass phase occurs is of importance in determining the behavior of a test piece made by dry pressing a finely ground mixture is shown in Figs. 4 and 5. In these figures, the curves marked 1 were obtained by measurements made on billets and the curves marked 2 by measurements on dry-pressed briquets of the same composition as the respective billets. In pressing the briquets, care was taken to use the same percentage of water and to press for the same length of time at the same pressure in all cases.

It will be observed that the two measurements on dry-pressed material, shown by the open and closed circles of curve 2 in Fig. 4, are in good agreement, while the two shown similarly in Fig. 5 deviate from each other over a considerable portion of the range of temperature covered. Comparison of the flow curves for the slags in the two cases shows that the irregular behavior of Fig. 5 is to be ascribed to the flow of the glass phase at a temperature so low that the gas evolved from the solid could not escape before it was trapped by the liquid. It is clear that a composition which behaves in

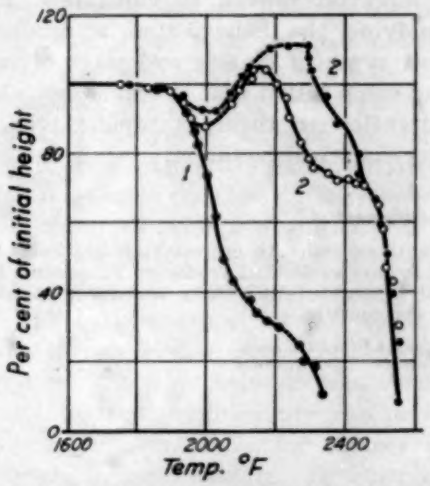

FIG. 5.—Comparison of behavior of billets and briquets.

the manner typified by curve 2 of Fig. 4 would make a good pyrometric cone powder, while one typified by curves 2 of Fig. 5 would not. Similarly a material which behaves like Fig. 4 would give better results in an enameling process than one behaving like Fig. 5.

VII. Extension of the Method to the Study of Interfacial Tension

It is frequently desirable to be able to form some estimate of interfacial tension between glasses or slags and solids. For example, in the

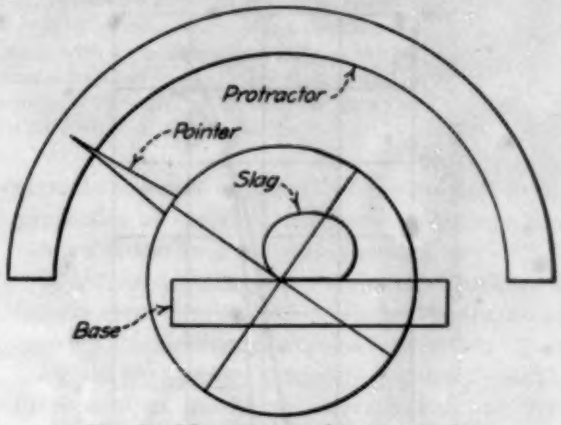

FIG. 6.—Measurement of contact angle.

porcelain enameling of metals it is desirable to know the minimum temperature at which the enamel will wet the metal. This may be done by a modification of the techniques previously described because the angle of contact between a drop of liquid, resting on a horizontal solid base, and the solid on which it rests is a function of the gas-liquid, the gas-solid, and the solid-liquid interfacial tensions. If the slope of the tangent to the liquid surface at a point of contact with the solid is negative (*i.e.*, the angle of contact is less than 90° and lies in the *second* quadrant), the sum of the gas-liquid and the solid-liquid interfacial tensions is greater than the gas-solid interfacial tension. Consequently, the liquid retains a lenticular shape and does not wet the solid, and the area of solid covered by the liquid is determined only by the mass of liquid and the equilibrium shape which is reached when the flattening effect of gravity is exactly balanced by the resultant of the surface forces. If, however, the slope of the tangent line is positive (*i.e.*, the angle of contact is less

NOTE: In the discussion which follows it is assumed that the point of contact under consideration is on the side of the drop toward the observer's left. Some such arbitrary assumption is necessary if "positive" and "negative" are to be used without confusion (see Fig. 6).

than 90° but lies in the *first* quadrant), then the gas-solid interfacial tension exceeds the sum of the other two interfacial tensions. Consequently, the resultant of the surface forces acts *with* gravity instead of *against* it; the liquid wets the solid and flows out over it.

In order to make measurements of contact angle, a pointer was attached to the cross-hair

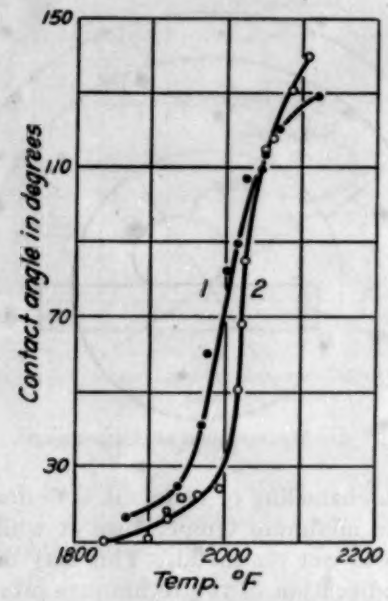

FIG. 7.—Increase of contact angle with rising temperature.

tube of the cathetometer telescope in such a way as to move over the scale of a protractor when the tube was so rotated as to keep one of the cross-hairs tangent to the liquid surface at a point of contact between liquid and solid as shown in Fig. 6. A billet of the material to be studied was placed in the furnace on a base of whatever substance it was desired to observe and the contact angle measured as the furnace temperature was raised at some predetermined rate.

Figure 7 shows curves of contact angle *versus* temperature for two alumino-silicate slags on a base of "Armco" iron. To avoid introducing a change of sign at 90°, angles in the second quadrant are represented as lying between 0 and 90°, those in the first quadrant as lying between 90° and 180°. Curve 1 is for a slag containing about 30% Fe_2O_3 and 2% CaO and curve 2 for a slag containing about 10% Fe_2O_3 and 5% CaO. It is interesting to note that the presence of a larger amount of Fe_2O_3 in slag 1 than slag 2 does not cause slag 1 to wet the iron at a significantly lower temperature than slag 2. It will be noted that the measurement of contact angle need not be made with high precision in order to determine quite accurately the temperature at which wetting begins because a large change in angle corresponds to a relatively small change in temperature.

VIII. Conclusion

Methods for studying the flow characteristics of glasses and slags at elevated temperatures have been described. It is not claimed that the techniques which have been described yield relative values of viscosity and surface tension which are independent of each other or are independent of superimposed effects dependent upon the conditions of measurement. They have, however, proved so valuable a means for studying the behavior of a number of different types of glasses and slags of widely varying composition that it seems desirable to call attention to them as rapid, facile, and effective empirical methods.

Acknowledgment

The authors desire to express their gratitude to the Central Pennsylvania Coal Producers' Association for the financial support of this study and for permission to publish this material.

PENNSYLVANIA STATE COLLEGE
STATE COLLEGE, PENNSYLVANIA

STRESS RELEASE IN GLASS
A PHENOMENON INVOLVING VISCOSITY AS A VARIABLE WITH TIME*

By Howard R. Lillie

Abstract

This paper contains a discussion of the well-known Adams and Williamson annealing law which makes the rate of release of stress in glass proportional to the second power of the stress and points out certain fundamental objections to such a law. A new expression free from these objections and taking into consideration the change of viscosity with time at constant temperature is given as $-df/dt = Mf\varphi$, where M is a modulus and φ the instantaneous fluidity. Experiments made with an ordinary lime glass show that this law holds for the release of mechanical stresses imposed on strain-free glass as well as for the release of thermal stresses in chilled samples. The value of M found for these two types of stress at two different temperatures is 5.9 ($\pm$0.5) $\times 10^{10}$ dynes/cm.^{2}.

I. Introduction

The object of this paper is not to discount in any way the significance either of the work done several years ago by Adams and Williamson[1] or of the conclusions reached by them concerning the manner in which thermal stresses are reduced in a glass by constant temperature treatment. The practical value of their results has been proved many times over; their empirical expressions for arriving at good annealing schedules are used, and doubtless will be used, with success. We shall, however, view the annealing phenomenon from a more fundamental standpoint, bearing in mind recently discovered facts which demonstrate quite clearly certain fundamental fallacies in the Adams and Williamson expression and at the same time point out qualitatively why the latter can be so accurate empirically.

Throughout this paper the view will be maintained that the type of annealing of particular interest to the glass industry consists in the release of stresses set up in the glass during rapid cooling and is concerned with constitutional or other secondary changes only as these in turn have their effect upon properties governing the stress release itself. That these properties do depend upon previous thermal history may become evident in an apparent difference between release rates for stresses introduced mechanically into previously strain-free glass and those for stresses having their origin in rapid cooling. If, however, the effect in both instances depends essentially upon the same process of stress removal, the two cases should become identical when the governing properties of the glass itself are adequately considered in the final analysis of results.

Moreover, in this paper the writer will adhere to the concept that stress release is brought about through the medium of viscous flow which allows the glass particles to gradually approach equilibrium average positions corresponding to zero stresses. Since such properties as elastic modulus, birefringence constant, density, etc., have been previously observed to be essentially constant, it can be readily believed that the viscosity coefficient, varying widely with both time and temperature, is the principal property governing stress release rates.

II. Discussion of the Adams and Williamson Law

Adams and Williamson found that a linear relation was obtained when the reciprocal of stress was plotted against time at a constant temperature. That is,

$$\frac{1}{f} - \frac{1}{f_0} = At \qquad (1)$$

Where f = stress at time t
f_0 = stress at time zero
A = "annealing constant."

The differential equation for this relation,

$$-\frac{df}{dt} = Af^2 \qquad (2)$$

requires that the rate of stress decrease be proportional to the second power of the stress itself.

If stress release is brought about by viscous flow and is also subject to Hooke's law, the relationship expressed by equation (2) is obviously contrary to what one would predict. Since laws of viscous flow require the rate of displacement of particles to be proportional to the stress, and since

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Glass Division). Received June 24, 1935.

[1] L. H. Adams and E. D. Williamson, "Annealing of Glass," *Jour. Franklin Inst.*, 190, 597 (also p. 835) (1920).

Hooke's law requires the change in stress to be proportional to this displacement, it follows directly that the rate of change of stress must be proportional to the stress to the first power. Adams and Williamson doubtless expected such a first-power relation to exist, but their data all directly indicated the second-power law stated above.

Bailey and Sharp[2] have pointed out one argument against the physical reality of equation (2) if it is to apply to mechanically induced stresses. Their argument will be briefly repeated here. Consider (Fig. 1) a slab of glass of half-thickness, a, placed under a bending load such that unit maximum stress at the surfaces will be observed. The stress distribution will be linear as shown by the line marked "zero time." Suppose the glass, *held constantly in this configuration*, is then subjected to such a temperature that in a time, t, the maximum stresses will fall to one-third of a unit. During this time, each fiber of glass in the lengthwise direction of the beam can be thought of as acting individually, the magnitude of its stress affecting in no way that in any other fiber. Thus, assuming equation (2) and a constant "annealing constant" (*i.e.*, independent of time or position), the stress distribution for times $t/4$, $t/2$, $3t/4$, and t can be readily computed. These are shown in Fig. 1. The S-shaped curve for time t, having maximum values of $^1/_3$ unit, has the same bending moment as a load which

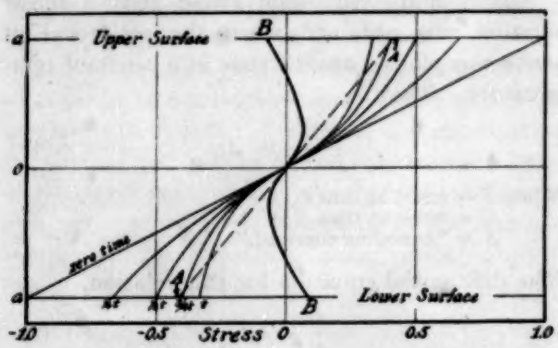

FIG. 1.—Mechanical stress release in perfect accord with Adams and Williamson law.

would cause a linear stress distribution, AA, having maximum stresses of 0.412 unit. In other words, at the time, t, the same load is being applied to hold the configuration of the beam constant as would cause a stress distribution, AA. Hence upon removal of the load, the values along AA will be subtracted, leaving a permanent residual stress shown by the heavy line, BB. To the author's knowledge, such curved lines or residual stresses have never been observed under the conditions stated.

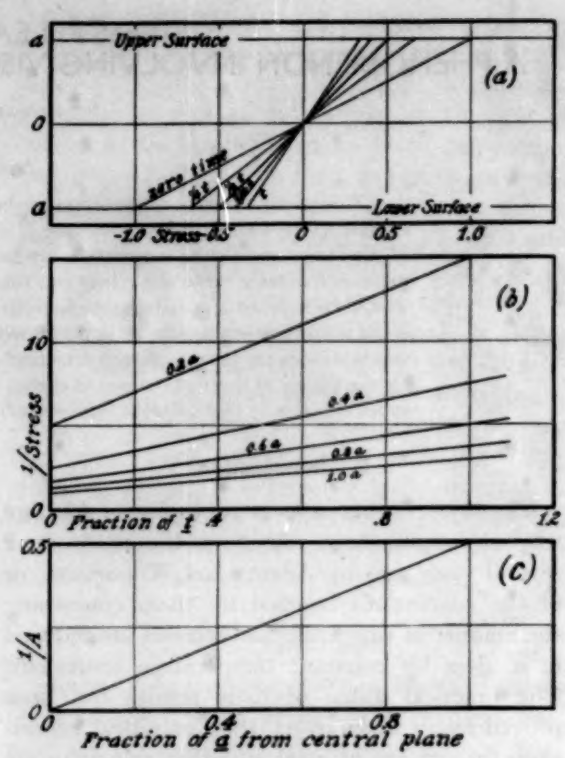

FIG. 2.—Analysis of observed mechanical stress release on the basis of the Adams and Williamson law.

An equally impossible conclusion is reached when experimentally observed effects are analyzed from the standpoint of the Adams and Williamson law, as pointed out by Bailey and Sharp.[3] Figure 2 (*a*) shows how the stress will actually be observed to decrease, the distribution being linear at all times. Figure 2 (*b*) shows $1/f$ plotted against time for various planes in the glass from center to surface. It may be seen from these plots that along any individual plane the Adams and Williamson law apparently holds true but that the annealing constant, A (slope of the lines), varies with position in the glass. Figure 2 (*c*) shows that the reciprocal of A is proportional to the distance of the plane of reference from the central plane of the glass. Now if A depends, as one naturally supposes, on

[2] James Bailey and D. E. Sharp, "Release of Strain in Glass," (Fig. 15, p. 377), *Jour. Amer. Ceram. Soc.*, **16** [8] 367–79 (1933).

[3] *Ibid.*, Figs. 16 and 17.

the glass fluidity (reciprocal of viscosity, the governing physical property as stated previously), then one reaches the absurd conclusion that the viscosity is proportional to the distance from the central plane.

Similar reasoning can be applied to the case in which the stresses are completely internal and not caused by externally applied forces. This case is much more complex than that cited above since release of stress at a single point causes reactionary releases at other points. It can be argued, however, that, if Adams and Williamson's law were true, the ratio of maximum compression to maximum tension would become progressively smaller with time, approaching unity as a limit. This effect has never been observed unless the surface chill has exceeded the internal chill to a sufficient extent to introduce an appreciable gradient in initial state.

One is forced to the conclusion, then, that some important physical property (most likely viscosity itself since this property has been found[4] to change with time) must vary with time to such an extent that the second-power law apparently holds true. That is, some function of f, η, etc., must be empirically equivalent to Af^2 under the conditions of the Adams and Williamson experiments.

The simplest expression which appeals to reason is

$$-\frac{df}{dt} = \frac{Mf}{\eta} \qquad (3)$$

in which M has the dimensions of a modulus (the same as those for a stress). Since η expresses a ratio between stress and rate of displacement of particles, a modulus expressing the ratio between change of stress and displacement is quite necessary to the expression. Thus, in a glass of low modulus, the rate of change of stress for a given value of f/η would be small, since much larger displacements are necessary to produce a given stress decrease.

III. Plan of Experiments

All of the foregoing discussion is more or less familiar ground, parts of which have been explored from time to time by Littleton,[5] Bailey and Sharp,[2] the writer, and others. It is believed, however, that previous experimental work has served only to show what questions remained unanswered and to indicate, roughly, possible answers to those questions. The principal shortcoming of the material to be found in the literature to date is that it fails to coördinate all the phases of the problem by means of a complete group of experiments, all with identical glass, at equal temperatures, and under rigorous control of temperature and previous heat treatment. For instance, it is known that the release of mechanical stress becomes progressively slower with repeated loadings, that the bending stress always has a linear distribution, that no residual stress is observed upon removing the load completely, that viscosity increases with time, approaching an apparently finite limiting value corresponding to infinite time, and that all these facts combine to make a qualitative picture of the mechanics of annealing. But nowhere in the literature are they combined to make this picture quantitative and persuasive.

The nearest approach to such a combination is in the data described by Littleton[5], which indicate the relation

$$-\frac{df}{dt} = {}^1/_4Gf/\eta \qquad (4)$$

for a lime glass at 460°C and 470°C. Even in these experiments, however, the previous thermal history of the samples was not controlled nor were the initial heating rates of the samples well enough equalized. In addition, no experiments were made on the release of mechanically introduced stresses.

The following experiments have accordingly been made: (*a*) ordinary annealing runs on large slabs of glass previously chilled under known conditions; (*b*) viscosity-time determinations on fibers actually chilled under conditions similar to those of the slabs in (*a*); (*c*) stress-release runs on beams of annealed glass held in a constant configuration by a heavy screw press; and (*d*) viscosity-time determinations on fibers annealed along with the beams in (*c*).

The samples used were all taken from large slabs poured consecutively; they are therefore as nearly identical as is possible. The glass is an ordinary lime-bulb glass, similar (within factory limitations) to that used in the Littleton experiments. All four individual experiments were

[4] H. R. Lillie, "Viscosity-Time-Temperature Relations in Glass at Annealing Temperatures," *Jour. Amer. Ceram. Soc.*, **16** [12] 619–31 (1933).

[5] J. T. Littleton, "Physical Processes Occurring in Melting and Cooling of Glass," *ibid.*, **17** [3] 43–49 (1934).

carried out at two temperatures, about 455°C and about 475°C. The greatest care was taken to have all heat treatments exactly parallel in the *a*, *b* and *c*, *d* combinations, while temperatures throughout the extended runs agreed within a degree. In the (*c*) experiments, repeated loadings were used, each time starting with about 2.25 kg./mm.^{2} maximum. The slabs in (*a*) started with about 4 kg./mm.^{2} maximum tension. In (*b*) and (*d*), the fibers were loaded to 3 kg./mm.^{2} in all cases.

IV. Apparatus and Technique

The apparatus and mode of procedure for the several sections of the experiments outlined above will be described briefly.

(a) Annealing of Chilled Slabs

These slabs were roughly 2 by 4 by $^5/_8$ inch. The ends were optically polished, while the remaining surfaces were smoothed. After preheating, these were placed for a short time in a muffle furnace at somewhat over 800°C and chilled suddenly to 440°C. For each annealing test, one of these slabs was fitted into a steel holder designed to slip into position in an electrically heated furnace. The birefringence (maximum tension) was observed through small holes in insulating plugs inserted in the ends of the furnace and was measured with a Babinet compensator in the usual way. Temperature readings were made by means of a chromel-alumel thermocouple inserted in the steel holder mentioned above. Control was maintained by means of a chromel-

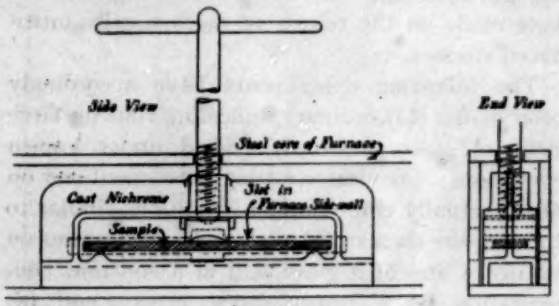

FIG. 3.—Apparatus for observing mechanical stress release.

alumel thermocouple imbedded in the furnace windings in conjunction with a Leeds and Northrup "Micromax" indicating controller.

Owing to the necessity of duplicating the heating curve of the slab when viscosity measurements should be undertaken, a special procedure was adopted for observing this curve directly. A "dummy" slab was poured into a graphite mold so as to imbed two platinum thermocouples, one near the surface, the other at the exact center. This "dummy" was then introduced into the

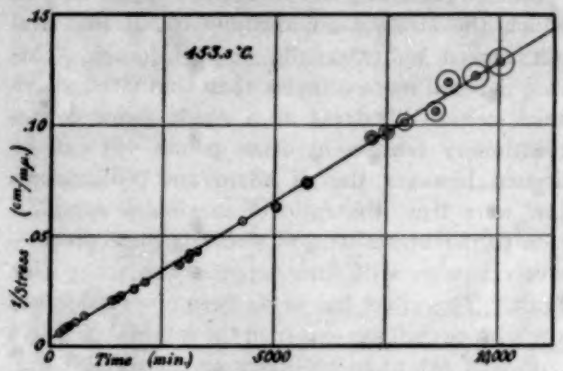

FIG. 4.—Adams and Williamson plot for thermal stress release at 453°C.

furnace exactly as planned for the other samples and observations of temperatures were taken during heating. It was found that 45 minutes were required to attain within 25° of the final temperature and 55 minutes for within 10°; further, that at no time did the two couples differ by more than about 5°C. This heating curve was closely duplicated in the (*b*) experiments.

(b) Viscosities of Chilled Fibers

As stated above, these fibers were chilled similarly to the slabs by suspending them in a small furnace and dropping them directly into the chilling bath. The apparatus and technique for measuring viscosities of fibers have been previously described[4] in detail.

(c) Release of Mechanical Stress

The beams used in these tests were 5 by 20 by 150 mm. in size, optically polished on all surfaces. In order to destroy any previous thermal history, the beams were held at 500°C for about 30 minutes after which they were cooled to room temperature in the furnace. Owing to an unfortunate circumstance requiring the repetition of part of the work, the beam and fiber used in the 455° experiment were treated separately from those used at 475°. The screw press used in the stress-release tests is shown diagrammatically in Fig. 3. The sample is placed in the press while cold, the furnace is then started, temperature-

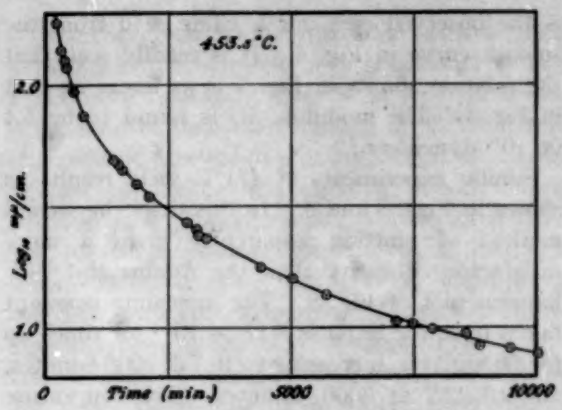

FIG. 5.—Logarithmic plot for thermal stress release at 453°C.

time curves being determined during heating by means of a thermocouple near the sample. The temperature is controlled as in (*a*). Birefringence measurements on the tension surface are made, also as in (*a*).

(d) Viscosities of Annealed Fibers

These fibers underwent the same 500° treatment simultaneously with the beams; after this treatment they were assumed to have the same thermal history as the beams. After inserting the fiber in the elongation apparatus, the temperature was raised by manual control along the temperature-time curve observed in (*c*).

V. Terms and Equations

The following symbols will be used:

Stress release

f = stress (mμ/cm.)
t = time (minutes unless otherwise noted)
A = annealing constant, as used by Adams and Williamson (cm./mμ/min.)
B/η = a constant suggested by Preston to replace A and take η into account

Viscosity measurements

η = viscosity (poises)
φ = fluidity in rhes = $1/\eta$
M = a constant having the dimensions of a modulus

In plotting results, all logarithms are to the base ten.

If, as suggested by Preston,[6] equation (5) may be written

$$-\frac{df}{dt} = Af^2 = \frac{B}{\eta} f^2 \qquad (5)$$

where η is assumed to be constant, then it follows that

$$\frac{1}{f} - \frac{1}{f_0} = At = \frac{B}{\eta} t \qquad (6)$$

But η has been proved conclusively to change with time. Obviously, then, a plot of $1/f$ *vs.* t should not be linear, and, in being so, it constitutes an indirect argument against the validity of the Adams and Williamson law as expressed in equation (5). This is because, *with η variable with time*, the differential equation of expression (6) (empirically true) is not (5) but is

$$-\frac{df}{dt} = \frac{Bf^2}{\eta} - \frac{f^2}{\eta}\left(\frac{1}{f} - \frac{1}{f_0}\right)\frac{d\eta}{dt} \qquad (7)$$

However, another expression (equation (3)), which is as sound dimensionally as equation (5), may be written as:

$$-\frac{df}{dt} = \frac{Mf}{\eta} = Mf\varphi \qquad (8)$$

If φ is assumed constant in this case, the solution is:

$$\text{Log } f_0 - \log f = M\varphi t \qquad (9)$$

A plot of $\log f$ *vs.* t is always found to be nonlinear, its slope, $d(\log f)/dt$, varying widely as a function of t. But φ also varies widely with t. Therefore, expressing equation (8) as

$$-\frac{d(\log f)}{dt} = M\varphi \qquad (10)$$

the values of $-d(\log f)/dt$, for various times, may be plotted against values of φ for the same times.

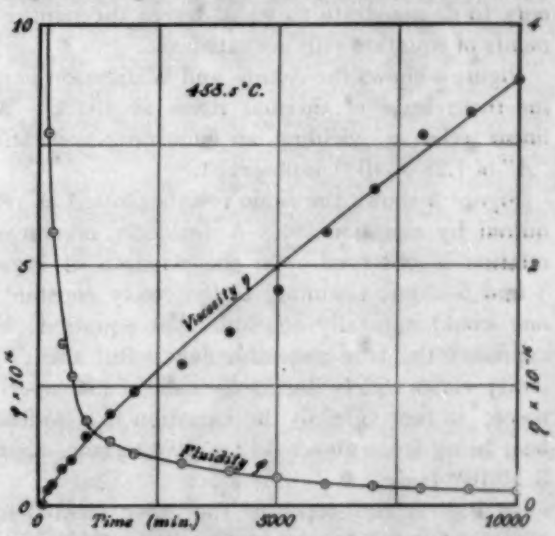

FIG. 6.—Viscosity- and fluidity-time curves for chilled fiber at 453°C. (This figure is plotted incorrectly; φ should be multiplied, and η divided, by 1.18 to give correct values.)

[6] F. W. Preston, "Fundamental Law of Annealing," *Trans. Opt. Soc.* [London], **26**, 270 (1924–25).

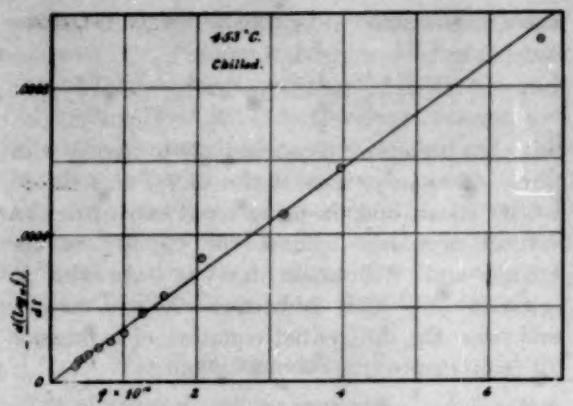

FIG. 7.—Plot showing linear relation between df/dt and $f\varphi$, thermal stress at 453°C.

Then, if a linear relation through the origin is found, the truth of equation (8) is indicated. Further, it is probable that the slope of such a plot, M, representing some modulus of the glass, should be independent of the type of stress involved and practically independent of the time or temperature. Indeed, M should vary between glasses only to the same degree as their moduli differ. Referring to the Young's modulus, 5.5 to 8.5 $\times$ 10^{11} dynes/cm.^{2} is considered a large variation between glasses, that of the present glass being about 6.8 $\times$ 10^{11}.

VI. Experimental Results

Since the plan of the experiments as well as the technical details has been described, it remains only to demonstrate to what degree the requirements of equation (10) are satisfied.

Figure 4 shows the Adams and Williamson plot for the release of thermal stress at 453°C. A linear relation, yielding an annealing constant "A" of 1.28 $\times$ 10^{-5}, is observed.

Figure 5 shows the same results plotted as required by equation (9). A decidedly nonlinear relation is observed. On the strength of Figs. 4 and 5 alone, assuming the viscosity constant, one would naturally conclude that equation (5) expresses the true annealing law. But the viscosity varies widely during the time of the experiment; in fact (Fig. 6) the variation is a 25-fold one, being from about 0.12 $\times$ 10^{16} to more than 3 $\times$ 10^{16} poises.

In Fig. 7, the slopes of the curve plotted in Fig. 5 (slopes taken at various values of t) are plotted against observed values of φ for corresponding times. At each time the fluidity used is the observed one, not a value read from the smooth curve in Fig. 6. It is readily seen that the relation shown in Fig. 7 is as linear as that in Fig. 4. The modulus, M, is found to be 5.4 $\times$ 10^{10} dynes/cm.^{2}.

Similar experiments at 471°C yield results as shown in Figs. 8 and 9. In this case, the second method of plotting apparently gives a more satisfactory linearity than the Adams and Williamson plot of Fig. 8. The annealing constant taken from the latter is 8.17 $\times$ 10^{-6} for times up to 900 minutes, increasing to 19.7 at 2000 minutes, and to 22.2 at 3000 minutes. This curvature will be discussed later. At this temperature, M is found to be 5.7 $\times$ 10^{10} dynes/cm.^{2}. This is derived from the slope of the line, disregarding the small intercept on the φ axis which remains unexplained.

The release of mechanically imposed stress was also observed at approximately the same two temperatures, using the apparatus of Fig. 3. Viscosities of annealed fibers were also observed as explained above.

Figure 10 shows four loadings in such a release test at 457° plotted in the Adams and Williamson manner. As has been observed by Bailey, the annealing constant, A, progressively decreases from one loading to the next. In these runs, A varies from 7.75 $\times$ 10^{-6} at the beginning of the first loading to 1.20 $\times$ 10^{-6} in the last loading. Comparing these values with 1.28 $\times$ 10^{-5}, observed for chilled stress at the same temperature, one can see how much the annealing constant changes with heat treatment. Obviously A is not a function strictly of composition and temperature as previously supposed.

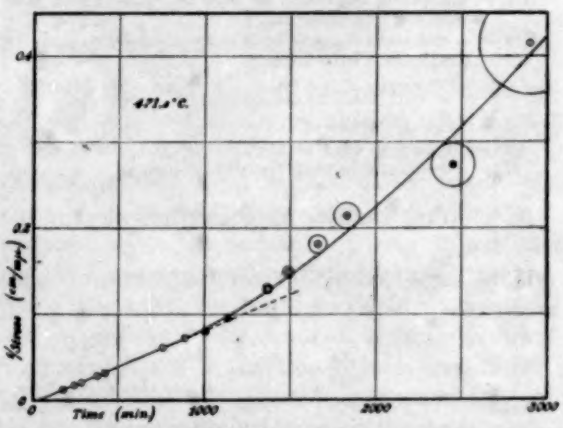

FIG. 8.—Adams and Williamson plot for thermal stress release at 471°C.

If, at a given temperature and with a given previous heat treatment, φ in equation (10) is a function of time only, then $-d(\log f)/dt$ is also a function of time, independent of f. Therefore it should be possible to plot logarithms of stresses against total time and make a smooth curve, provided the proper amount is subtracted from the logarithms during the individual loadings. This has been done in Fig. 11, appropriate amounts being subtracted to yield a smooth curve. For instance, in the third loading, 0.739 is subtracted from all values in order to make the curve for this loading fall on a continuation of the plot of the second loading. In order to make sure that the composite curve made up in this way is the same as one for a single loading, a check test was run extending to about 4200 minutes. The result agreed so well with Fig. 11 that at no time did the slopes differ by so much as 5% (which would correspond to about 0.6° difference). This check test also served to show that the anomalous high rate of stress release immediately following the application of each new load is an elastic reaction which apparently takes place within the structural groupings of the glass and is independent of any real viscous flow. This anomalous release can therefore be neglected in dealing with the viscous phases of the problem. A corresponding reaction probably takes place directly following the application of the first load but disappears before 100 minutes have elapsed, the time for which the first slope to be plotted in Fig. 12 was determined.

Figure 12 shows an analysis of these results in a manner similar to that of Fig. 5. The value of M in this experiment is 6.8×10^{10} dynes/cm.^{2}.

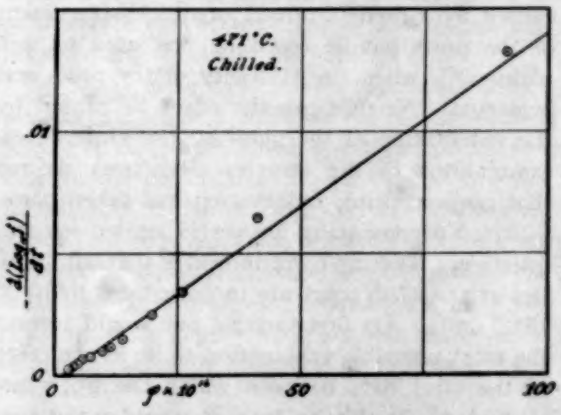

FIG. 9.—Plot showing linear relation between df/dt and $f\varphi$, thermal stress at 471°C.

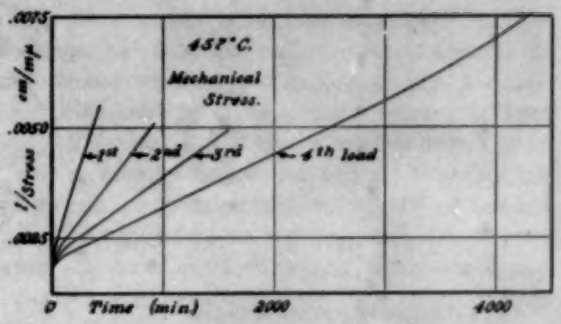

FIG. 10.—Adams and Williamson plot for mechanical stress release at 457°C.

Figure 13 is a plot similar to that in Fig. 11, the temperature now being 473°, showing the same effects only to a somewhat smaller degree. In Fig. 14, there is a surprisingly close similarity to Fig. 9 for chilled stress at about the same temperature, not only in slope and degree of linearity but also in the small intercept on the φ axis. In this case, M is again in fair agreement with those found for the first cases described, being 5.6×10^{10} dynes/cm.^{2}. On the other hand, the annealing constant, A, varies from 1.34×10^{-5} in the first loading to 0.37×10^{-5} in the last, as compared with about 10×10^{-5} for thermal stress release. Again the same conclusions cited above become obvious.

VII. Conclusion

Table I shows a condensed summary of the results of the experiments. It is readily seen that the annealing constant, A, is not a function strictly of glass composition and temperature, and that M may be considered a constant essentially independent of temperature and previous thermal history, representing a modulus of the particular glass. It may therefore be said with little doubt that equation (8) is a true and correct statement of stress release.

VIII. Discussion

There are certain questions which it would be of interest to discuss briefly:

(1) How can the anomalous release rate following each reloading in Figs. 11 and 13 be interpreted?
(2) What is the meaning of the finite intercept in Figs. 9 and 14?
(3) Is there any relationship between M and a known mechanical modulus?
(4) How does it happen that in the case of ther-

TABLE I

SUMMARY OF RESULTS

Type	Temp. °C		A	M
Chilled samples	435		1.28×10^{-8}	5.4×10^{10}
	471		8.17×10^{-8} up to 900 min.	
			19.7 at 2000 min.	5.7×10^{10}
			22.2 at 3000 min.	
		Loading		
	457	1st	7.6×10^{-8}	
		2nd	3.25	6.8×10^{10}
		3rd	1.80	
		4th	1.20 increasing at end	
Mechanically stressed annealed samples				
	473	1st	1.34×10^{-8}	
		2nd	0.87	
		3rd	0.66	5.6×10^{10}
		4th	0.52	
		5th	0.37	

Mean M 5.9 ($\pm$0.5) $\times 10^{10}$

mal stress the plot of $1/f$ *vs.* time is so exactly linear?

(5) Can any practical use be made of the annealing law as expressed in equation (8)?

To the writer, there is no exact answer to any of these questions. The discussions which follow are surmises, based chiefly on experience.

(1) It is believed that this effect represents an elastic reaction which has no relation to real viscous flow. Glass is generally thought to be composed of rather large and very complex groupings. When a shearing stress, for instance, is applied, one can imagine some of this force being relatively quickly removed by a fast reaction inside the distorted aggregates. As the temperature is increased, the effect should become smaller since viscous flow increases in proportion to the elastic reaction. It may be said with confidence that the effect is not caused either by elasticity of the apparatus or by flow of the apparatus. Referring again to Fig. 11, the 457° stress-time observations plotted both for a glass about 200° harder than that under discussion and for fused silica are seen. (In this latter case 0.120 has been subtracted from each reading to compensate for the higher birefringence constant of fused silica. The stress applied at zero time was the same in all cases.) Obviously any flow in the nichrome press must be very small indeed. Another experiment showed that the birefringence caused by a predetermined angular displacement of the press handle could be predicted to well within 3% when the elasticity of the press was neglected. Neither can the effect be caused by the indentation of the glass by the knife edges; examination of the samples after tests showed that no perceptible indentation had taken place.

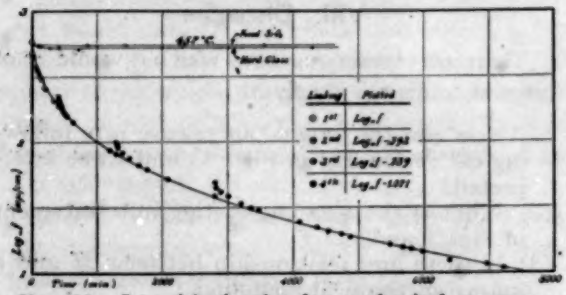

FIG. 11.—Logarithmic plot for mechanical stress release at 457°C.

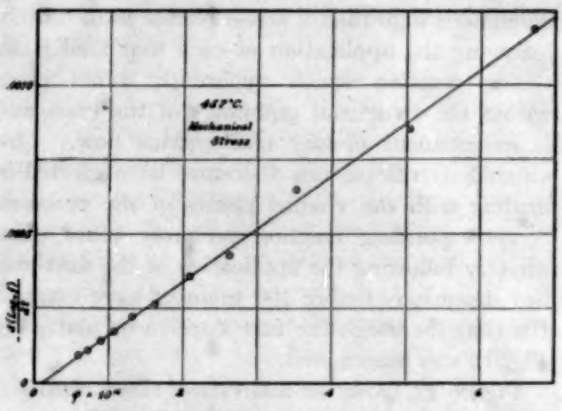

FIG. 12.—Plot showing linear relation between df/dt and $f\varphi$, mechanical stress at 457°C.

(2) No convincing answer is known for this question. The intercept indicates that all fluidities at the 470° point are in error by 3 to 10 $\times$ 10^{-16} units. On first thought one would suspect the most plausible explanation to lie in the creep of the steel rods between which the fibers are elongated. If this be true, it would mean that the metal changes in this property by a very large

factor, between 450° and 470°, since the effect is not observed at the lower temperature. Further, since the rods had a cross-section area forty times that of the fibers, the metal fluidity would have to be at least 10^{-14}, which seems quite large. Moreover, a test was made at 475°C with the result that no elongation of the rods could be detected

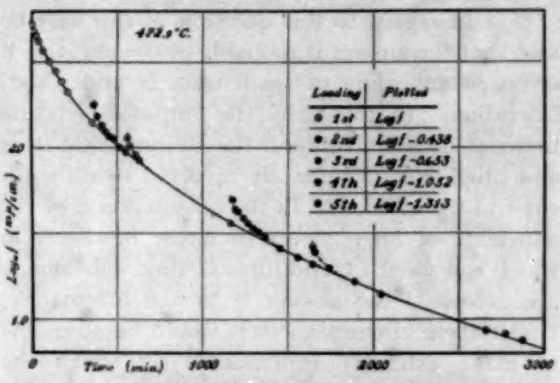

FIG. 13.—Logarithmic plot for mechanical stress release at 473°C.

during a period of three days. The intercept could also be interpreted as indicating plasticity, but such an effect should presumably become more pronounced with decreasing temperatures.

(3) The constant, M, may not have any direct relation to known mechanical moduli since it possibly refers to a stress-strain ratio in a molecular rather than a macroscopic sense. The following relationship has been noted however: The Young's modulus of the glass is 6.8×10^{11} dynes/cm.[2], while its Poisson's ratio is taken to be 0.24. The shear modulus, G, is therefore 2.74×10^{11}, which makes M equal to G divided by four or five. No physical significance is attached to this odd relation; it is quoted only as an interesting observation. As mentioned previously, Littleton gave this value as $G/4$.

(4) The empirical Adams and Williamson relation expressed in equation (6) is not followed exactly at all temperatures, the deviations in fact being in the direction indicated by the new law embodied in equation (8). Neither is Preston[7] justified in arguing that if both equations are correct, the fluidity must be proportional to the stress and therefore must become zero in a perfectly annealed glass. Such a statement involves an extrapolation to infinite time, one which few of us dare make. One can only say that the fluidity-time function and the stress-time function bear a certain relationship to one another, each representing an approach toward a final state, that final state being a small finite value in the one case and zero in the other. Whether the fluidity is progressing toward a zero or toward 1% of its initial value certainly can not be read from an experiment in which both stress and fluidity are allowed to change by a factor of only ten.

In this connection, Fig. 15 shows four kinds of stress variation plotted first as logarithmic values and second as reciprocals. Curve No. 1 is that which would be observed for a material of constant viscosity, a condition never present in glass annealing. Curve No. 2 represents a condition in which the viscosity increases for a time at such a rate as to make the Adams and Williamson plot linear and then reaches a steady value. This is the type of curve usually observed in an ordinary lime glass at a temperature near its strain point if the stress is allowed to reach as low as 5 mμ/cm. The curve in Fig. 8, as well as the end of the fourth loading in Fig. 10, are examples of this type. Curve No. 3 represents the case in which the Adams and Williamson plot is really linear, such as that shown in Fig. 4. In this case, throughout the length of the experiment, the fluidity bears a constant relation to the stress but does so simply because of previous and prevailing conditions. Presumably, if a similar stress could be produced but with a widely different thermal history involved, this constant relation would no longer exist. Curve No. 4 is

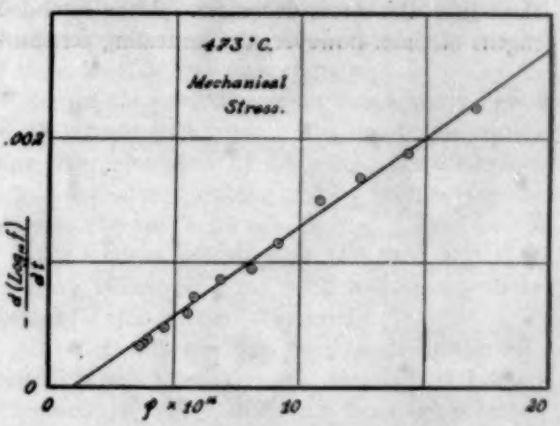

FIG. 14.—Plot showing linear relation between df/dt and $f\varphi$, mechanical stress at 473°C.

[7] F. W. Preston, "The Great Enigma," *Glass Ind.*, 15 [4] 57 (1934); *Ceram. Abs.*, 13 [7] 176 (1934).

for the case in which the annealing constant, A, decreases appreciably during the first part of the run and then becomes constant. This type is regularly observed at lower temperatures than those reported here. It indicates that at the outset the viscosity increases proportionately faster than the stress decreases. After extended lengths of time, however, the annealing constant should increase slightly as the viscosity changes more slowly and approaches the equilibrium value. Such a curve has been observed by Morey[8] in the annealing of Pyrex-brand glass at 425°C, but it is quite uncertain whether an increase in A occurred in the last stages of the test, the stress being too small for a very precise measurement of its reciprocal.

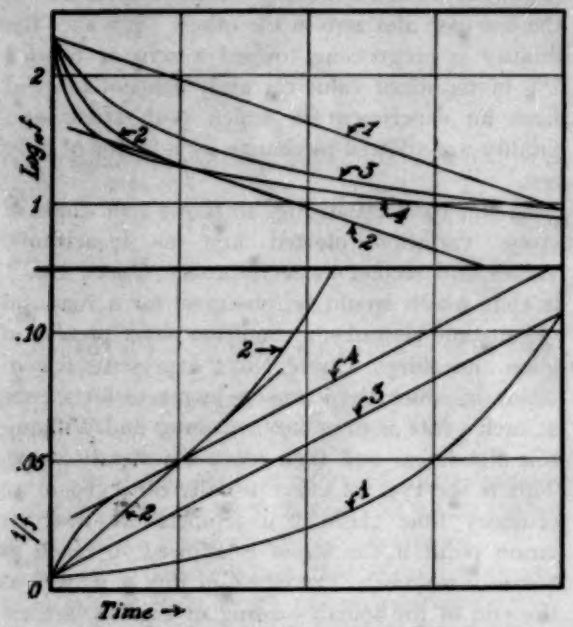

FIG. 15.—Plotting and interpreting stress release rates.

(5) In regard to this question, it can only be said that the answer is probably in the negative if ordinary annealing of small ware is under consideration. In this case, the empirical relation between stress and time is the all-important item and small enough times are involved to allow for cut-and-try methods. In the consideration of the annealing of huge pieces of glass, however, in which enormous expenditures of time and money are involved, the answer is in the affirmative. Under these circumstances it would be advisable to make extensive experiments by which the necessary factors could be learned to transform equation (8) into the most appropriate annealing schedule.

CORNING GLASS WORKS
CORNING, NEW YORK

[8] George W. Morey, "Annealing of Pyrex Chemical Resistant Glass," *Ind. Eng. Chem.*, 27 [8] 966 (1935). In a recent letter to the author, Morey states that his results can be interpreted to indicate a slight increase in A during the last half year, but that (in view of the precision) the same data would not positively preclude even an actual *decrease* in A in the same period.

EFFECT OF MILL PRACTICE AND MILL ADDITIONS ON THE OPACITY OF ENAMELS*

By G. L. Bryant and F. R. Porter

Abstract

The results are presented on work done to increase the opacity of enamels by mill practice and mill additions, such as milling to abnormal fineness, addition of opacifiers at the end of the milling period, the effect of the addition of feldspar, and the effect of different types of clays.

I. Introduction

As has been previously described by Porter and Holscher,[1] opacity is believed to be caused by the reflection, refraction, and diffraction of light which is incidented upon the enamel surface. It is also thought that the reflection is due to the presence of crystalline[2] and gaseous phases in the glass having a different index of refraction from that of the surrounding glass.

To develop maximum opacity, it will be necessary to foster and preserve the crystalline and gaseous phases present and to prevent them from being dissolved by the glass.[2c] It is the object of this paper to show how this can be effected by better selection of materials for the mill batch and by the development of better milling procedure.

II. Procedure

(1) Preparation of Panels in Ground Coats

The panels for opacity determinations were prepared by shearing 20-gage enameling stock into panels 4 by 6 inches. Cleaning and pickling were accomplished by running the panels in the same basket with the regular run of ware. The following schedule was used in the pickle room: (1) cleaning tank, 40 minutes, (2) cold water rinse, (3) pickle (7% sulfuric acid) 40 minutes, (4) cold water rinse, and (5) neutralizer, 2 minutes. The cleaning tanks were kept boiling, the pickle tanks at 150 to 160°F and the neutralizer at 180°F.

The panels were dipped in ground coat at $1^1/_4$ to $1^1/_2$ ounces per square foot and were fired in a continuous electric furnace with the regular run of 20-gage stove ware at a dial setting of 1560°F.

The panels in the ground coat were carefully weighed on a scale sensitive to 0.01 gram. Owing to drafts and moisture remaining on panels from handling, duplicate readings could only be obtained within 0.05 gram. With a maximum variation of 0.05 gram on two readings, a maximum error of 0.6 gram per square foot was obtained.

The panels were sprayed with the enamel to be tested, using a cup gun with the reservoir above the gun at 60 pounds air pressure. Care was taken to keep the nozzle of the gun approximately 12 inches from the surface of the panel. The panels were roughly weighed while they were being sprayed to obtain the approximate weight of the enamel desired on each panel.

The panels were thoroughly dried and weighed to the nearest 0.01 gram. The weight per square foot was calculated by obtaining the difference before and after spraying and by multiplying the difference by the factor 6.

Each enamel was fired at the time and temperature which previous work had shown to be correct for that particular enamel.

All reflectance readings were made on the McGean (sometimes termed the Priest-Lange) reflectometer. Five different spots were tested on each panel; an average of 4 readings was taken on each spot, giving an average of 20 readings for the average opacity of each 4- by 6-inch panel.

Previous work on milling[3] white cover-coat enamels showed that fine grinding increased the

---

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

[1] F. R. Porter and H. H. Holscher, "Use of Finely Milled Enamel Slips," *Jour. Amer. Ceram. Soc.*, 18 [2] 39–42 (1935).

[2] (*a*) G. Agde and H. F. Krause, "Effect of Fluoride Additions to Glasses and Enamels, II," *Z. angew. Chem.*, 40, 804 (1927); Enamel Bibliography, p. 2, published by the American Ceramic Society, May, 1929.

(*b*) G. Agde, H. F. Krause, and W. M. Lehmann, "Behavior of Fluorides in Glasses and Enamels, III," *Z. angew. Chem.*, 40, 886 (1927); Enamel Bibliography, p. 3.

(*c*) A. I. Andrews, G. L. Clark, and H. W. Alexander, "Progress Report on Determination of Crystalline Compounds Causing Opacity in Enamels by X-ray Methods," *Jour. Amer. Ceram. Soc.*, 14 [9] 634–39 (1931).

[3] C. Kühn, "Influence of Number and Size of Particles on Covering Power," *Farben-Ztg.*, 31, 1131–33 (1926); *Ceram. Abs.*, 5 [9] 268 (1926). See also footnote 1.

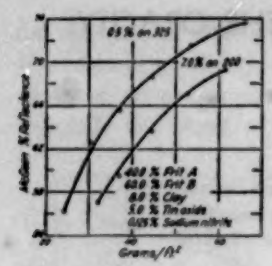

FIG. 1.—Effect of fine grinding on opacity (frits A and B).

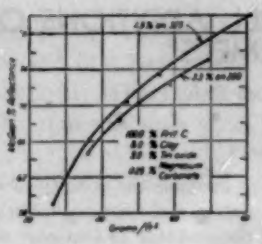

FIG. 2.—Effect of fine grinding on opacity (frit C).

opacity of enamels. It was decided to check this procedure to see whether or not a difference in frit composition made any difference in the benefits obtained by fine grinding. Accordingly, the following duplicate batches were milled to approximately 6% on a 200-mesh screen and to 1% on a 325-mesh screen (see Figs. 1, 2, 3, 4, and 5).

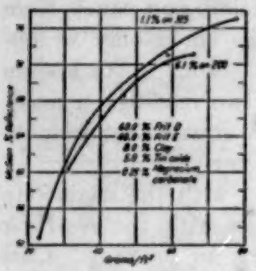

FIG. 3.—Effect of fine grinding on opacity (frits D and E).

The effect of fine grinding on tin-oxide substitutes is shown in mill batches 9 and 10 (Fig. 5).

(2) Effect of Tin Oxide on Opacity

The usual method of producing opacity in porcelain-enamel finishes is by the addition of tin oxide to the mill batch. X-ray analyses have shown the presence of tin-oxide crystals in the enamel.[2c] Hence, it may be assumed that the opacity is due largely to this crystalline phase which reflects the light. To ascertain how much tin oxide could be added before its maximum effect in producing opacity was reached, the mill batches (see Fig. 6) were weighed up so that the amount of tin oxide in each batch was increased in 2% increments until no increase in opacity was noted.

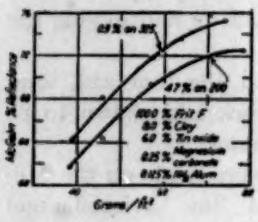

FIG. 4.—Effect of fine grinding on opacity (frit F).

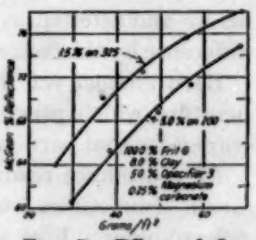

FIG. 5.—Effect of fine grinding on opacity (frit G).

(3) Effect of Types of Clays on Opacity

Three different clays were studied: two were prepared clays and the third was a lump, or German Vallendar, clay. Batches of each type were milled to determine the effect of clays on opacity (see Fig. 7).

(4) Effect of Adding Tin at the End of Milling Period

Previous work[2] showed that opacity is the result of two or more existing phases present in the enamel. It was thought that adding tin oxide at the close of the milling period would result in increased size of the tin particles which would perhaps be less soluble in the glass. Mill batches were made up, as shown in Fig. 8, one in which tin was included and one in which the tin was omitted. The mills were ground to fineness, the tin was added to the batch in which it

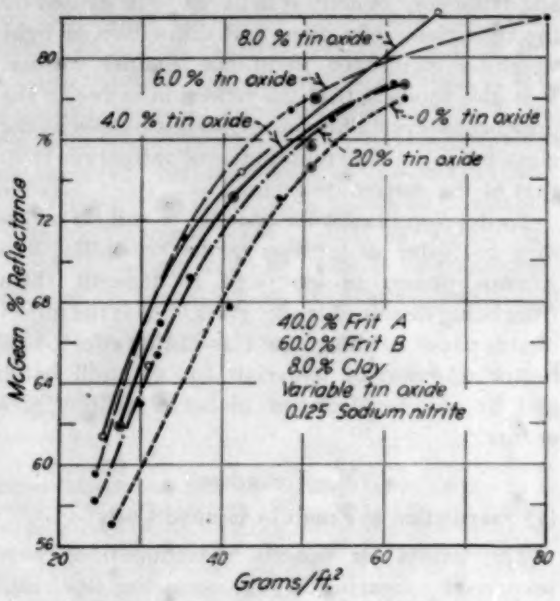

FIG. 6.—Effect of tin oxide on opacity (frits A and B).

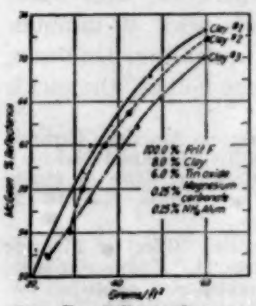

FIG. 7.—Effect of type of clays on opacity.

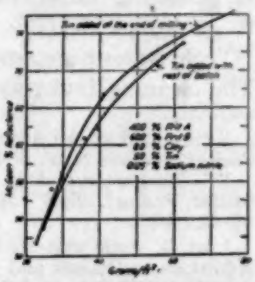

FIG. 8.—Effect of adding tin at the end of the milling period.

had been omitted, and both mills were run 15 minutes longer to insure uniform mixture of tin and to give both mills the same treatment.

(5) Addition of Feldspar to Mill Batch after Milling

Since it seems necessary to promote the existence of two or more phases in the enamel glass, it was thought that if the tin-oxide particles could be surrounded by a refractory material, such as feldspar, the solubility of the tin oxide would be decreased and the opacity would be accordingly increased. It is also possible that some of the feldspar, if it remained undissolved, might itself contribute to the opacity. The following batches were milled, and the tin oxide and feldspar were added after the milling was completed (see Fig. 9).

Mill batch No.	21	22	23	24
		(Weight in grams)		
Frit A	400	400	400	400
Frit B	600	600	600	600
Clay	80	80	80	80
Tin oxide	50	50	50	50
Feldspar		20	40	60
Sodium nitrite	1.25	1.25	1.25	1.25
Water	500	500	500	500
Residue on 325-mesh	0.6	0.8	0.7	0.9

(6) Effect of Tin-Oxide Substitutes on Opacity

Three different tin-oxide substitutes were tried in two different enamels, and the effect on opacity was determined (see Figs. 10 and 11).

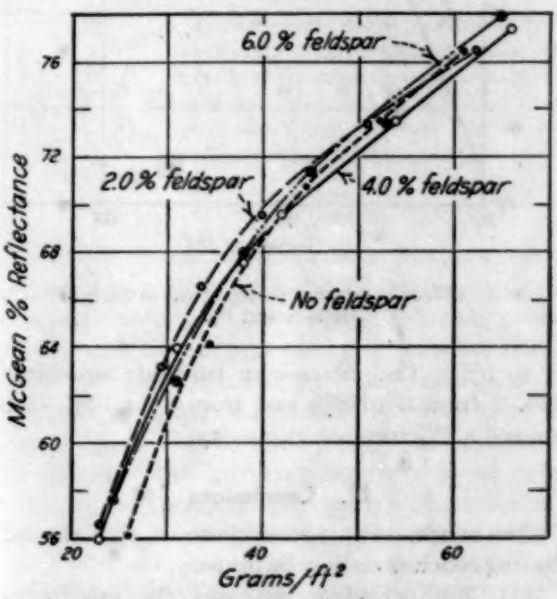

FIG. 9.—Effect of feldspar additions at end of the milling period.

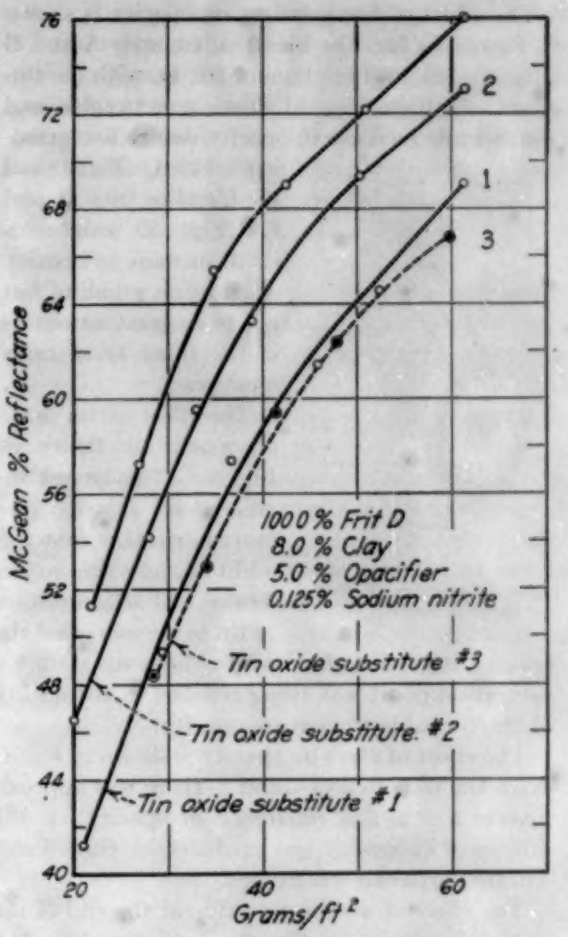

FIG. 10.—Effect of tin-oxide substitutes on opacity (frit D).

(7) Effect of Tin Oxide and Tin-Oxide Substitute No. 2

Previous work in this report has shown that saturation is obtained in some highly opaque enamels by using 6% tin oxide in the mill batch. It was thought that by adding two di erent opacifiers the results would be additive and in this way the saturation point could be raised above the opacity obtained with 6% tin oxide. Accordingly, the following batches were milled so that opacifier No. 2 was increased in 2% increments (see Fig. 12).

Mill batch No.	33	34	35	36	37	38
			(Weight in grams)			
Frit A	400	400	400	400	400	400
Frit B	600	600	600	600	600	600
Clay	80	80	80	80	80	80
Tin oxide	40	40	40	40	40	40
Opacifier No. 2		20	40	60	80	100
Sodium nitrite	1.25	1.25	1.25	1.25	1.25	1.25
Water	500	500	500	500	500	500
Residue on 325-mesh	0.6	0.7	0.6	0.8	0.9	0.6

The effect of fine grinding on opacity is shown in Figs. 1 to 5. The blend on enamels A and B (Fig. 1), frit F (Fig. 4), and frit G, with the tin-oxide substitute (Fig. 5) shows a noticeable and worth-while increase in opacity due to fine grinding. Frit C (Fig. 2) and the blend of frits D and E (Fig. 3) exhibit a small increase in opacity due to fine grinding but not to as great extent as in the other three cases mentioned.

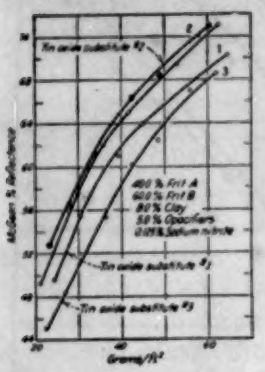

FIG. 11.—Effect of tin-oxide substitutes on opacity (frits A and B).

The effect of tin oxide on opacity is shown in Fig. 6. The largest increase in opacity occurred with the first 2% addition of tin oxide. The 4 and 6% addition of tin oxide increased the opacity only a slight amount, indicating that a saturation point was being reached in the ability of the tin oxide to increase opacity.

The effect of clays on opacity is shown in Fig. 7. With the use of clays 1 and 2, there was approximately a 1 to 2% difference in opacity; a 4% difference in opacity was produced by clays 1 and 3 in the particular frit studied.

The effect of adding tin oxide at the end of the milling is shown in Fig. 8; approximately 1½ to 2% increase in opacity was obtained by this variation in milling procedure.

The effect of feldspar additions to the mill is shown in Fig. 9. The effect of the feldspar is to give a more rapid rise in opacity at the lower application weights. The effect of feldspar diminished at weight values of more than 40 grams per square foot. The 2% addition of feldspar gave the highest increase in opacity. Each additional increase in feldspar after the original 2% decreased the opacity from the maximum value. The increase in refractoriness in the enamel and no change in firing time and temperature may account for the decrease in opacity. It was found impossible to adopt this method of increasing opacity on a commercial basis because the feldspar added in this manner caused pitting.

The effect of tin-oxide substitutes on opacity is shown in Figs. 10 and 11. Frit D (Fig. 10) produced more opacity with tin oxide than any of the tin-oxide substitutes. The nearest substitute produced 4% less opacity than tin oxide. A blend of frits A and B (Fig. 11) produced more opacity with tin-oxide substitute No. 2 than with tin oxide. The tin-oxide substitutes are closer to tin oxide in producing opacity in the blend of enamels A and B than in frit D.

The effect of two different opacifying agents in the mill batch is shown in Fig. 12. The two largest increases in opacity were obtained by the 2 and 4% additions of tin-oxide substitute No. 2. A small increase in opacity was obtained by increasing the tin-oxide substitute No. 2 from

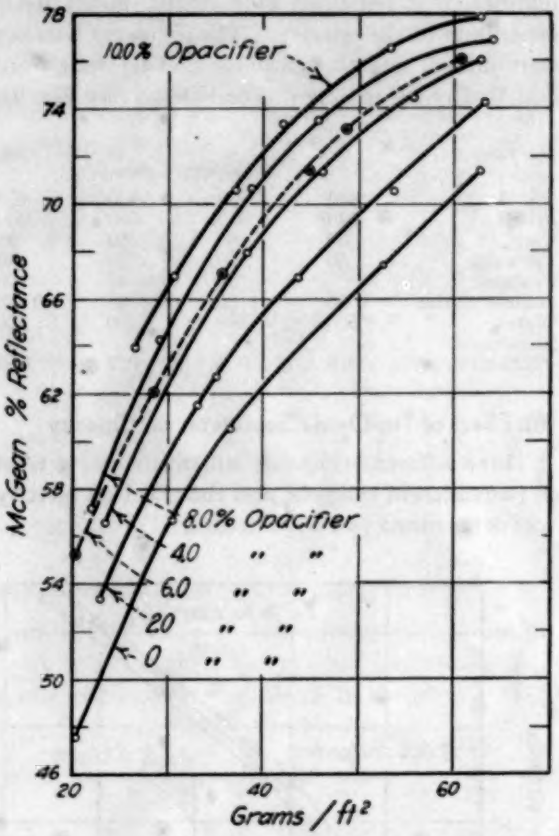

FIG. 12.—Effect of two opacifying agents in the mill batch (frits A and B).

4 to 6%. The increase in tin-oxide substitute No. 2 from 6 to 8% and from 8 to 10% each caused a 2% increase in opacity.

III. Conclusions

The results of this study indicate that the following conclusions may be drawn:

(1) Fine grinding increases the opacity of enamels, but the effect is greater in some types of

enamels than in others. The results seem to show that the cost of fine grinding would make the increase in opacity due to fine grinding rather doubtful in the case of enamels of type C and in the blend of enamels D and E.

(2) The addition of tin oxide increases opacity up to 6% in the blend of frits studied. The addition of tin oxide beyond 6% would be of rather doubtful value in increasing opacity of this type of enamel.

(3) The type of clay added to the mill batch materially affects the opacity of the enamel. This is a field in which very little work has been done and the results indicate that an increase in opacity can be accomplished by keeping and adhering to a close specification of the opacity imparted to enamels by clay added to the mill batch.

(4) The addition of tin oxide at the end of the milling period increased the opacity over the tin oxide added at the beginning with the mill batch in the frit studied. This seems to indicate that it is necessary to grind the enamels fine but not the opacifier when the latter is within definite grain-size limits. The increase is rather small but would result in a saving of from 3 to 4 grams per square foot.

(5) The addition of feldspar to the mill batch at the end of the milling period increases the opacity of some enamels at weight values under 40 grams per square foot. This is, perhaps, due to surrounding the tin-oxide crystals by a protective ring of feldspar particles and preventing the solution of tin oxide in the enamel glass or to the imparting of opacity by the undissolved portion of the feldspar.

(6) The introduction of tin-oxide substitutes in the mill batch in some cases produces as much opacity as tin oxide. This is entirely dependent upon frit composition.

(7) The addition of two opacifying agents to the mill batch makes it possible to overcome the saturation of opacity obtained with 6% tin oxide in certain types of enamels. The amount of opacity obtained from an enamel is limited only by the amount of opacifying agents which can be loaded into the enamel without adversely affecting the physical properties of the enamel or making the cost too great.

Edison General Electric Appliance Co.
5600 West Taylor Street
Chicago, Illinois

EFFECT OF CLAYS ON THE OPACITY OF WHITE ENAMEL FOR SHEET STEEL*

By R. R. Danielson

Abstract

The various means for developing the maximum covering power of enamels are very important. This investigation brings out the marked effect on the opacity of different clays used for suspending cover enamels. This may be equivalent to at least 5% in the reflectance, as measured by the reflectometer. Where suspension and opacity are both important, a blend of clays may be used, one of which may have excellent suspension while the other imparts opacity to the enamel.

I. Introduction

In the search for more opaque enamels, careful studies have been made by the manufacturers of enamel materials, by those producing enamel frits, and by the operators of enameling plants. The use of improved materials and frits has opened up fields of manufacture which were not considered a few years ago. The means for developing the maximum covering power of enamels are, therefore, important and particularly interesting to the producers of enameled ware.

II. References

The importance of suitable preparation of an enamel for the development of maximum opacity was probably first shown by Sweely and Prince[1] in their work on the effect of fineness of grinding on the opacity of enamels. Their findings were probably not fully appreciated at the time because of the lack of control of operations and the absence of practical means for measuring opacity. Since that time, the general adoption of the reflectometer as a practical means for measuring

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division). Received May 11, 1935.

[1] B. T. Sweely and E. S. Prince, "Relation of Fineness of Grinding to Opacity in White Enamels," *Jour. Amer. Ceram. Soc.*, 5 [12] 855 (1922).

opacity has resulted in numerous studies of materials and shop operations which might affect the opacity of enamels.

Porter and Holscher[2] have recently presented some excellent work on the use of finely milled enamel slips in developing the maximum opacity of enamels. They have shown that the reflectance can be increased at least 2% by increasing the fineness of the enamel over the ordinary range of grinding for commercial enamels. Their work also indicates that reflectance increases rapidly with the application of additional enamel up to the quantity required for good opacity. It is evident, therefore, that less than normal applications can be made only at the expense of quality unless more opaque frits and enamel material are used or advantage is taken of special processing which will maintain the required opacity.

The type of clay used for the suspension of cover enamels is another important factor in the development of opacity, but apparently it has been given little consideration by most users of enamels. McIntyre[3] has discussed the effect of clays on the opacity of enamels, although no data have been presented to show the wide differences in opacity obtained with clays now in use. Data on the opacity obtained with various types of enameling clays should therefore be of interest to those concerned with the development of maximum opacity of cover enamels.

III. Experimental

Eight typical clays now in use in the enameling industry were milled with a standard white frit of moderate opacity according to the following mill formula: 100 frit, 6 clay, 6 tin oxide, 0.25% magnesium carbonate, and the necessary water, depending on the properties of the clay. The enamels were milled to give a residue of 1.0 to 2.0% on a 200-mesh screen, as determined by the standard fineness test of the Enamel Division.[4]

The enamels were applied by spraying on 20-gage, 6- by 10-inch ground-coated plates. A total of thirty grams of enamel, equivalent to 72 grams of enamel per square foot, was made in two applications and firings.

The opacity was determined on a Zeiss reflectometer against baryta white as a standard. The results are shown in Table I and are an average of 40 readings on each of four plates.

TABLE I

EFFECT OF CLAYS ON REFLECTANCE OF ENAMEL

Clay No.	Source	Reflectance (%)
	Individual clays	
1	Domestic	76.5
2	Imported	76.2
3	"	75.9
4	"	74.9
5	Domestic	73.5
6	"	72.4
7	"	72.3
8	"	71.5
	Blended clays	
9	Blend of 50% No. 1 and 50% No. 7	74.2
10	Blend of 50% No. 2 and 50% No. 7	74.0

The individual clays result in a range of reflectance for the enamels from 71.5 to 76.5%. This difference of 5% is very large, as it is possible to distinguish the apparent opacity between enamels having a difference of 1% reflectance.

It happens that the clays which impart the greatest opacity to enamels do not ordinarily have the property of giving the best suspension. In the spraying of enamels, however, suspension is not such a difficult matter, and greater advantage can be taken of the opacifying effect of certain clays.

There are, however, instances where the suspension properties of cover enamels become of equal importance to the opacity. In the manufacture of some ware, draining or dipping is preferable to spraying as a means for enamel application. In this event, opacity must be sacrificed to working properties or a compromise must be reached by blending two clays, one of which may have ideal suspension properties while the other may impart high opacity to the enamel.

The effect of such blending of clays is indicated in Table I for blended clays 9 and 10. Clay No. 1 imparts high opacity to an enamel, while clay No. 7, which does not have this property, is a very plastic clay and particularly valuable where enamel suspension is involved. A blend of 50% each of these two clays, indicated as clay No. 9, gives a reflectance value which is approximately a mean of the values for the two clays used in the blending. The suspension is improved over that for clay No. 1 and should be suitable for dipping and draining enamels. The same general

[2] F. R. Porter and H. H. Holscher, "Use of Finely Milled Enamel Slips," *Jour. Amer. Ceram. Soc.*, **18** [2] 39–42 (1935).

[3] G. H. McIntyre, "Recent Enameling Clay Development," *Enamelist*, **12** [2] 18 (1934); *Ceram. Abs.*, **14** [3] 63 (1935).

[4] "Report of Enamel Division Standards Committee, 1930" *Bull. Amer. Ceram. Soc.*, **9** [9] 269(1930).

effect on reflectance and suspension is obtained for blended clay No. 10, which is a blend of 50% each of clays No. 2 and No. 7.

IV. Conclusions

The importance of clays in producing opaque enamels for minimum thickness of coating can not be overlooked in view of the fact that the reflectance imparted by two clays may vary 5%, as measured by the reflectometer. The user of wet-process enamels, therefore, must give more consideration to the selection of clays for suspending cover enamels. Where suspension and opacity are both important, a blend of clays may be used, one of which may have excellent suspension while the other imparts opacity to the enamel.

Metal & Thermit Corporation
Carteret, N. J.

OFFICIAL DIVISION PERSONNEL 1935—1936

(For *Art Division*, see Organization Chart shown on page 392, December, 1935, issue)

	Enamel	Glass	Materials and Equipment	Refractories	Structural Clay Products	Terra Cotta	White Wares
Trustee	W. C. Lindemann	J. T. Littleton	V. V. Kelsey	R. B. Sosman	R. B. Keplinger	R. L. Clare	P. D. Helser
Chairman	R. M. King	U. E. Bowes	C. H. Peddrick, Jr.	R. B. Sosman	A. F. Greaves-Walker	J. L. Carruthers	T. A. Klinefelter
Vice-Chairman		J. S. Gregorius	H. B. DuBois	R. E. Birch			
Secretary	B. J. Sweo	S. R. Scholes	J. E. Eagle	H. M. Kraner	G. H. Duncombe	H. E. Davis	S. J. McDowell
Nomination	(a) H. G. Wolfram (b) J. D. Tetrick	(a) J. T. Littleton (b) E. W. Tillotson	(a) George Simcoe (b) C. W. Gerster	(a) R. A. Heindl (b) H. E. White	D. A. Moulton R. B. Keplinger	(a) E. C. Hill (b) D. F. Albery	(a) E. H. Fritz (b) R. F. Sherwood
Editorial	T. D. Hartshorn R. D. Cooke B. A. Rice	G. V. McCauley G. E. F. Lundell E. W. Tillotson	C. C. Treischel J. E. Eagle G. H. Brown	H. E. White R. B. Sosman R. K. Hursh	Ellis Lovejoy J. O. Everhart J. W. Whittemore	H. G. Schurecht H. E. Davis E. C. Hill	S. J. McDowell R. F. Geller H. F. Vieweg
Papers and Program	G. H. McIntyre Frank Porter Warren Copp N. G. Wedemeyer	J. S. Gregorius	H. F. Kleinfeldt	N. W. Taylor K. W. Smith S. F. Walton	W. C. Rueckel	J. L. Carruthers	V. J. Roehm
Membership	W. V. Knowles	Donald Sharp	R. B. Carothers	G. J. Easter	D. F. Stevens H. C. Kleymeyer	Thaddeus O. Smith	J. W. Hepplewhite
Research	W. N. Harrison	G. W. Morey	G. H. Brown	D. W. Ross	G. H. Duncombe	Hewitt Wilson	F. H. Riddle
Standards *(a) Tests* *(b) Products*	(a) D. G. Bennett (b) Frank Hodek	W. C. Taylor	(a) R. C. Meeker (b) B. C. Burgess	(a) R. S. Bradley (b) E. H. Van Schoick	(a) J. L. Carruthers (b) H. D. Foster	(a) H. E. Davis (b) H. G. Schurecht	F. P. Hall
Education	W. H. Pfeiffer	J. C. Hostetter	B. T. Bonnot	F. A. Harvey	D. A. Moulton		A. S. Watts
Data	C. R. Amberg	A. N. Finn	G. F. Metz		T. W. Garve		G. A. Loomis
Rules	R. D. Landrum	W. M. Clark	Fred Bell	K. E. Buck	Howells Frechette		Edward Schramm
Management	H. E. Ebright		F. A. Guignon	C. E. Bales	C. F. Tefft		Donald Hagar
Statistics	K. R. Groener		G. W. Cooper	L. C. Hewitt			J. R. Beam
Councillors	Frank Hodek R. B. Schaal W. N. Harrison A. I. Andrews	G. W. Morey Herbert Insley	Philip Dressler R. L. Cawood				Edward Schramm
Exhibitions			Tom Falknor				Tom Falknor
Symbols and Nomenclature				F. J. Williams E. P. Barrett			

CERAMIC ABSTRACTS

Compiled by the
AMERICAN CERAMIC SOCIETY

Ross C. Purdy, Editor

Abstracters: G. H. Abbott, Abde Ally, J. B. Austin, A. A. Ayars, Rudolf Barta, M. H. Berns, L. T. Brownmiller, W. H. Bruckner, Peter Budnikoff and E. Stefanowsky, P. T. Clark, W. M. Cohn, M. V. Condoide, Maurice Delangre, R. W. Devillers, J. L. Gallup, J. D. Gat, Max Hartenheim, M. J. Hausman, F. G. Heck, R. A. Heindl, E. B. Hewitt, G. M. Hutt, Herbert Insley, Hellmut Klaus, Seiji Kondo, J. M. Krappe, J. T. Littleton, Jr., E. H. McClelland, S. I. Perkal, C. J. Phillips, J. G. Phillips, R. H. H. Pierce, Jr., Alexis Pincus, R. W. Ryan, M. C. Shaw, G. R. Shelton, H. E. Simpson, H. Smith, H. H. Stephenson, L. E. Thiess, Gilbert Thiessen, Herbert Türk, E. J. Vachuska, F. E. Vaerewyck, F. J. Zvanut.

The bold-face number following the journal name is the volume; the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Vol. 15 **February, 1936** **No. 2**

Abrasives

Abrasive wheels: factors affecting their manufacture, selection, and application. J. Dummelow. *Crushing-Grinding*, 2 [7] 225–29 (1934); abstracted in *Referat. Silikatliteratur*, No. 913 (1934).—The composition, properties, and uses of natural and artificial abrasives are dealt with. M.V.C.

Abrasives and polishing agents for optical glass. E. Hertel. *Schleif & Poliertech.*, 12 [1] 5 (1935).—The usual abrasives are pure loose quartz sand, loose electrocorundum, silicon carbide with ceramic bond, and diamond. Natural emery is seldom used. For polishing, different qualities of iron oxides (potée rouge) are employed. Particulars are given concerning granulometry. H. discriminates between fine and "big" optics. F.E.V.

Accurate grinding machines. O. L. Breidenbach. *Schleif & Poliertech.*, 12 [5] 92 (1935).—German grinding machine works have developed successfully in recent years. Methods adopted are different from those of the U.S. because economical organization is widely different. New grinding machines have a strong frame to avoid vibrations and are driven by several separate electromotors. Different velocities, if continuous regulation is not compulsory, are realized by alternate current motors with switching poles. Oil drive has become important. Superiority of mechanical, electrical, or hydraulic regulation is still an open question. To reduce loss of time for champing, taking off, etc., devices using pressed oil, pressed air, and electricity are used. Control of the worked surface is secured during grinding, and, in some cases, operation is automatically interrupted by a recorder at the end of the process. F.E.V.

Development and standardization in abrasive technic. J. Daschner. *Schleif & Poliertech.*, 12 [1] 7 (1935).—D. gives a historical account, describing results actually reached and possibilities of international standardization. Preliminary studies concern abrasive wheels, granulation, hardness, securing of revolving disks, and label and compulsory inscriptions. F.E.V.

Fundamentals of grinding wheels with ceramic coatings. P. Postel. *Schleif & Poliertech.*, 12 [5] 94 (1935).—Ceramic bond is rather new compared with magnesite. P. gives a historical outline. Hardness of a grinding wheel is quite different from hardness of the abrasive matter; it means the strength which fastens individual grains. To obtain the same hardness of wheel with emery, dark technical or clear corundum, different bonds are required. Testing machines are dealt with. Means of obtaining different hardnesses are given. Ceramic coating is a clay which contains enough fluxes, or to which sufficient fluxes are added, to give by heating a glaze sufficient to fix the abrasive grains. Bonds will sinter or melt according to temperature. F.E.V.

Grinding disks of high porosity. H. Fritz. *Schleif & Poliertech.*, 12 [1] 1 (1935).—Until recently grinding disks were characterized by (1) nature of abrasive, (2) dimension of grains, (3) nature of bond, and (4) hardness. Texture is also important. Total porosity is usually less than 50%, and each single pore is smaller than the grain. A new process allows fabrication of grinding disks of high porosity (50 to 70%) with pores much bigger than the average individual grain. Distribution of pores is uniform, the surface very rough, and specific gravity small. Thin walls of abrasive matter are very efficient, chips going in the pores whence they are projected by centrifugal force. Loss of abrasive matter, in weight, is reduced by half. Elastic materials and soft and hard steels are treated successfully. Heat evolved is much less than usual. Balancing is easier. These disks allow great velocity and are convenient for automatic and semiautomatic grinding. F.E.V.

Importance of finishing surfaces. K. Hegner. *Schleif & Poliertech.*, 12 [5] 87 (1935).—Perfect finishing is

required to increase efficiency of machines and their durability. Two kinds of finishing should be discriminated: (1) smoothness without precision measurements, to improve the appearance, and (2) technical correctness. Exact measurements, geometrical form, and smoothness are prescribed within certain limits. Examples are given and testing machines are described. F.E.V.

Manufacture of abrasive disks, their properties and application. ANON. *Schleif- & Poliermittel.-Ind.*, No. 5–6, pp. 33–35 (1934); abstracted in *Referat. Silikatliteratur*, No. 1787 (1935).—A step by step description of the manufacture of an abrasive disk is given: (1) grinding the raw material, (2) sifting to the proper grain size, (3) mixing with the properly prepared bonding material, (4) pressing the mix in a hydraulic press with a pressure of 50 to 200 kg./sq. cm., (5) drying, and (6) firing in saggers to 1280 to 1410°C. Ceramic bonded disks are most commonly used; disks with a silicate bond are less strong and are used for finer work. Where strong thin disks are required rubber bond is used; this permits more rapid turning than disks with a ceramic bond. Shellac bond makes an even thinner and finer disk. Artificial resin bond is also used. M.V.C.

PATENTS

Abrasive. GERHARD BALLE, FRANZ GROM, AND KARL WOLF (I. G. Farbenindustrie A.-G.). U. S. 2,023,191, Dec. 3, 1935 (Aug. 2, 1934).

Abrasive article. OLIVER VANIER (Carborundum Co.). U. S. 2,021,160, Nov. 19, 1935 (July 3, 1933).

Abrasive device. J. L. BALLASH AND PAUL BUCHEISTER (Sterling Grinding Wheel Co.). U. S. 2,023,041, Dec. 3, 1935 (April 16, 1935).

Abrasive wheel. F. H. MANCHESTER (Wingfoot Corp.). U. S. 2,024,591, Dec. 17, 1935 (Dec. 4, 1933).

Auxiliary spindle for grinding wheels. JOHN BATH AND S. W. BATH (John Bath & Co.). U. S. 2,021,536, Nov. 19, 1935 (March 6, 1933; July 5, 1935).

Buffing wheel and method of making. R. T. KENT. U. S. 2,024,691, Dec. 17, 1935 (July 13, 1934).

Centerless grinding machine. H. H. ASBRIDGE (Churchill Machine Tool Co., Ltd.). U. S. 2,023,720, Dec. 10, 1935 (Aug. 7, 1931).

Clamping device. C. M. RUTTER (Republic Steel Corp.). U. S. 2,021,243, Nov. 19, 1935 (Aug. 10, 1932).

Crowning and concaving device for roll grinding machines. H. E. BALSIGER (Landis Tool Co.). U. S. 2,025,010, Dec. 17, 1935 (March 31, 1932).

Drill grinding machine. EDWARD BAUSCH AND W. L. FLAD (Bausch & Lomb Optical Co.). U. S. 2,024,268, Dec. 17, 1935 (June 2, 1932).

Duplex grinding machine. JOHN BATH AND S. W. BATH (John Bath & Co.). U. S. 2,021,535, Nov. 19, 1935 (March 6, 1933).

Feed control. H. E. BALSIGER (Landis Tool Co.). U. S. 2,023,777, Dec. 10, 1935 (July 18, 1932).

Gear grinder. H. D. TANNER (Pratt & Whitney Co.). U. S. 2,022,061, Nov. 26, 1935 (Sept. 9, 1933).

Grinding or abrading machines. NORTON CO. Brit. 438,702, Dec. 4, 1935 (Aug. 13, 1934). B. WALTERS AND W. M. DOBSON. Brit. 438,854, Dec. 4, 1935 (May 9, 1935).

Grinding machine. F. M. GERTISER (Cincinnati Grinders, Inc.). U. S. 2,024,283, Dec. 17, 1935 (March 1, 1933). P. S. JACKSON (Sundstrand Machine Tool Co.). U. S. 2,021,602, Nov. 19, 1935 (May 3, 1933).

Grinding machine feeding mechanism. H. A. SILVEN (Norton Co.). U. S. 2,023,704, Dec. 10, 1935 (May 5, 1933).

Grinding of rotating eccentric knives. W. E. MOLINS. U. S. 2,022,569, Nov. 26, 1935 (Dec. 2, 1933).

Grinding wheel feeding mechanism. A. G. BELDEN AND H. A. SILVEN (Norton Co.). U. S. 2,022,646, Dec. 3, 1935 (July 20, 1931).

Hydraulically operated automatic cam grinding machine. A. G. BELDEN AND H. A. SILVEN (Norton Co.). U. S. 2,022,178, Nov. 26, 1935 (April 16, 1932).

Hydraulically operated grinding machine. C. G. FLYGARE AND W. H. WOOD (Norton Co.). U. S. 2,022,542, Nov. 26, 1935 (April 28, 1933).

Lapping block. F. F. HILLIX (American Steel and Wire Co. of New Jersey). U. S. 2,024,999, Dec. 17, 1935 (April 19, 1935).

Lead screw correcting device. S. W. BATH AND E. A. WALKER (John Bath & Co.). U. S. 2,021,537, Nov. 19, 1935 (July 13, 1934).

Means for measuring the hardness of abrasive disks. H. BARTHEL, G. SCHÄFER, AND A. SCHÄFER (trading as Kugel-Fischer Erste Automatische Gusstahlkugelfabrik vorm. F. Fischer). Brit. 438,554, Dec. 4, 1935 (Nov. 3, 1933).

Polishing device for rolls of rolling mills. E. H. WAHLERT. Brit. 439,041, Dec. 11, 1935 (May 25, 1934).

Roll grinder for leather dressing machines, etc. E. H. VAN VALKENBURGH. U. S. 2,023,347, Dec. 3, 1935 (Feb. 25, 1935).

Rubber-bonded abrasive article. R. H. MARTIN (Norton Co.). U. S. 2,022,893, Dec. 3, 1935 (Aug. 31, 1934).

Setting head for machines for the grinding of worms. GABRIEL LECHESNE (Paul Durand). U. S. 2,023,329, Dec. 3, 1935 (March 16, 1935).

Tempering of glass. PILKINGTON BROS., LTD., AND W. B. CLITHEROW. Brit. 438,389, Nov. 27, 1935 (Sept. 8, 1934).

Treatment of abrasive tools. GERALD WHITE (Libbey-Owens-Ford Glass Co.). U. S. 2,022,530, Nov. 26, 1935 (Jan. 19, 1935).

Trimming mechanisms for grinding wheels. GEAR GRINDING CO., LTD., AND A. H. ORCUTT. Brit. 437,172, Nov. 6, 1935 (April 11, 1935).

Art and Archeology

Chinese art. BASIL GRAY. *Fortnightly Rev.*, No. 824, pp. 219–26 (Aug., 1935).—The modern movement in art against humanist standards and toward abstraction makes it easier to understand Chinese art, which is the great abstract art of the world. An exhibition held at Burlington House, London, was unparalleled for its wealth of Chinese art. H.H.S.

Design and the glass industry. E. M. FRY. *Jour. Soc. Glass Tech.*, **19** [75] 120–40*P* (1935); for abstract see *Ceram. Abs.*, **14** [9] 206 (1935). A.A.

Development in the decoration of ceramic products. W. B. KERR. *Ceram. Age*, **24** [4] 119 (1934).—The development of decalcomanias is briefly described. F.G.H.

Grand palace of Mari explored in Syria. ANON. *Sci. News Letter*, **28** [758] 249 (1935).—Ruins of a huge palace have been partially unearthed at Mari, Syria, by a French expedition sent out by the Louvre Museum. Kitchens, baths, and other rooms still containing articles used by the king and his court have been found. H.S.

Modern British-Roman art glass. ANON. *Clay Prod. Jour. Australia*, **2** [12] 2 (Oct., 1935).—Glass manufacturers in Britain are obtaining inspiration for their latest table pieces from the exquisite ware that is occasionally unearthed on old Roman sites. H.H.S.

Potteries of the Gulf coast. P. E. COX. *Ceram. Age*, **25** [4] 116–40; [5] 152–56; [6] 196–98 (1935).—The prominent potters and potteries of the Gulf coast are described and illustrated. F.G.H.

Pre-Columbian ceramics in Peru. G. LIVERANI. *Ind. Vetro & Ceram.*, **8** [3] 110–13 (1935).—The exhibition of pre-Columbian art in Rome gave opportunity to Mazzini to publish a well-illustrated book on Peruvian ceramics. Chimu tribes in the north and Nazca in the south developed interesting artistic pottery. Raw materials were found in the country, but the potter's wheel and high temperature firing remained unknown. Chimu ceramics is anthropomorphic with intense plastic expression while Nazca polychromy is decorative, symbolic, and totemic. F.E.V.

Red glazes and underglaze red by reduction. C. M. HARDER. *Jour. Amer. Ceram. Soc.*, **19** [1] 26–28 (1936).

Ruins of Quirigua. ANON. *Discovery*, **16**, 268–71 (Sept., 1935).—The work of Morris and Stromsvik for the Carnegie Institution is described and illustrated. Guatemala now depicts the antiquities of the country on its postage stamps. H.H.S.

Scientific problems in the fine arts. P. D. RITCHIE. *Discovery*, **16**, 258–60 (Sept., 1935).—The application of X-rays, microanalysis, etc., to the study of art products is described. H.H.S.

Secrets of Byzantium. J. H. BAXTER. *N. Y. Times Mag.*, p. 7 (Nov. 17, 1935).—The discovery of ancient mosaics supposedly of the 5th or 6th Century and belonging to the Sacred Palace built by Justinian is described. The stones or tesserae are mostly quarter-inch cubes; the shades of color are delicately graded and number more than 30; the craftsmanship is worthy of the best period of Byzantine art, being natural, flowing, and graceful. It is a magnificent piece and is almost the only specimen of its kind that exists to provide a means of studying and understanding this branch of Byzantine art as practiced in the capital. M.V.C.

BOOKS

Designs on the Prehistoric Pottery of Arizona. ELEANOR P. CLARKE. University of Arizona, 76 pp., 34 plates. Price $1.00. Reviewed in *Sci. News Letter*, **28** [758] 255 (1935).—Following a description of various pottery types, C. analyzes the patterns, finding that fifty design elements were used 705 times on the 220 pieces of pottery studied. A number of the illustrations are in color. H.S.

Stamped and Inscribed Objects from Seleucia on the Tigris. ROBERT H. MCDOWELL. University of Michigan Press, 1935. 280 pp. Price $3.50. Reviewed in *Sci. News Letter*, **28** [756] 224 (1935).—Evidence regarding official seals and stamps used in the period of Seleucid control of Babylonia is presented. The residence of a wealthy family is the chief source of the seal and stamp impressions described. H.S.

PATENTS

Apparatus for comparing color effects. H. H. SHELDON (Sheldon Electric Corp.). U. S. 2,022,326, Nov. 26, 1935 (April 30, 1932).

Apparatus for comparison of colors. H. H. SHELDON (Sheldon Electric Corp.). U. S. 2,022,327, Nov. 26, 1935 (June 28, 1932).

Decalcomania paper. LEWIS DAVIS (McLaurin-Jones Co.). U. S. 2,023,803, Dec. 10, 1935 (May 31, 1934). A decalcomania paper comprises a suitable backing sheet, a water-resistant coating carried by the sheet to take decalcomania printing, and a protective coating of resinous water-resistant material between the first-mentioned coating and the sheet, the protective coating being substantially insoluble in a solvent which readily dissolves the other coating.

Designs for:

Bottle. W. R. LEACH (Carr-Lowrey Glass Co.), U. S. 97,855, Dec. 17, 1935 (Oct. 24, 1935). A. I. LORENZEN (Owens-Illinois Glass Co.). U. S. 97,611, Nov. 26, 1935 (Oct. 3, 193 5). J. S. STEELMAN (Whitall, Tatum Co.). U. S. 97,748, Dec. 3, 1935 (Oct. 15, 1935).

Cabinet for a refrigerator. ALBERT KAHN. U. S. 97,851, Dec. 17, 1935 (Oct. 3, 1935).

Drinking glass. DONALD DESKEY (Libbey Glass Mfg. Co.). U. S. 97,594 to 97,597, Nov. 26, 1935 (Aug. 19, 1935).

Glass dish. EVERETT WORTHINGTON (McGraw Electric Co.). U. S. 97,693 and 97,694, Dec. 3, 1935 (Sept. 30, 1935).

Goblet. E. B. BEDFORD AND M. P. FLEMING (Oneida Community, Ltd.). U. S. 97,755, Dec. 10, 1935 (Oct. 4, 1934). ANDREW J. CUNNINGHAM (Cataract-Sharpe Mfg. Co.). U. S. 97,668 to 97,674, Dec. 3, 1935 (Oct. 2, 1935).

Jar. E. W. FUERST (Owens-Illinois Glass Co.). U. S. 97,600, Nov. 26, 1935 (Sept. 21, 1935). U. S. 97,847, Dec. 17, 1935 (Oct. 21, 1935). A. I. LORENZEN (Owens-Illinois Glass Co.). U. S. 97,774, Dec. 10, 1935 (Oct. 3, 1935).

Pitcher. F. S. TRUMBULL. U. S. 97,876, Dec. 17, 1935 (Oct. 4, 1935).

Plate. KARL BAYREUTHER (Rosenthal China Corp.). U. S. 97,797, Dec. 10, 1935 (Sept. 25, 1935).

Refrigerator cabinet. JOHN TJAARDA (Briggs Mfg. Co.). U. S. 97,875, Dec. 17, 1935 (April 26, 1935).

Saucer. KARL BAYREUTHER (Rosenthal China Corp.). U. S. 97,798, Dec. 10, 1935 (Sept. 25, 1935).

Water closet. J. A. CALLAHAN (Briggs Mfg. Co.). U. S. 97,839, Dec. 17, 1935 (April 26, 1935). JOHN TJAARDA (Briggs Mfg. Co.). U. S. 97,874, Dec. 17, 1935 (April 26, 1935).

Cements

Causes of corrosion of mortar and concrete. C. R. PLATZMANN. *Werkstoffe & Korrosion*, **10** [11] 53–56 (1935).—The resistance of mortars and concrete to atmospheric and chemical influences is investigated as dependent on their manufacture and composition. Alumina cements are chemically resistant and set quickly. They should, however, never be mixed with Portland or blast-furnace cements (as is often done for economical reasons because they are expensive); such mixture does not set very well and two rapid reactions take place by the action of one or two mols of $Ca(OH)_2$ on alumina cement:

(1) $CaO{\cdot}Al_2O_3+Ca(OH)_2+6.5H_2O = 2CaO{\cdot}Al_2O_3{\cdot}7.5H_2O$
(2) $CaO{\cdot}Al_2O_3+2Ca(OH)_2+3.8H_2O=3CaO{\cdot}Al_2O_3{\cdot}5.8H_2O$.

The sand or gravel used in the mixture must not contain too many organic impurities as they delay setting considerably; clayey and loamy substances, especially, must be kept low. The maximum content of loam or clay in mixtures for structures under high stresses should not exceed 3%, for medium stresses 5%, and low stresses (ordinary mortar) 7%. Carbon-containing constituents should be excluded. If cement has been stored very long and has absorbed CO_2, the quality of the resulting concrete is greatly deteriorated. Mortar and concrete must always be thoroughly and uniformly mixed, as otherwise pockets of unmixed material are formed giving rise to cracks. Insufficient tamping sometimes leads to corrosion as reinforcing rods start rusting which increases the volume and causes cracks. Sugar solutions cause softening of the concrete. Many examples illustrate the manner in which corrosion was caused. M.H.

Chemistry of Portland cement: II, Hydrated calcium salts. L. FORSÉN. *Zement*, **24** [6] 77–82 (1935).—Portland cement containing much lime will liberate, while reacting with water, a certain amount of $Ca(OH)_2$ which causes formation of basic calcium salts. F. and Klingstedt have investigated two series of crystallized basic salts: $CaO{\cdot}CaX_2{\cdot}3H_2O$ (X being NO_3, NO_2, ClO_3, ClO_4, or CrO_4) and $3CaO{\cdot}CaX_2{\cdot}15H_2O$ (with X for Cl, Br, I, or ClO_4) these last ones lacking stability. The following alumina compounds have been identified as crystals: $2CaO{\cdot}Al_2O_3{\cdot}7H_2O$ ($5H_2O$); $3CaO{\cdot}Al_2O_3{\cdot}6H_2O$ ($6H_2O$); $3CaO{\cdot}Al_2O_3{\cdot}12H_2O$ ($6H_2O$); $3CaO{\cdot}Al_2O_3{\cdot}18H_2O$ ($6H_2O$); $4CaO{\cdot}Al_2O_3{\cdot}13H_2O$ ($7H_2O$). After drying at 105°C or by P_2O_5, the number of water molecules indicated in parentheses remains. To obtain homogeneous crystals, different conditions of concentration, temperature, and time are required. Some double salts of low solubility have been identified: $3CaO{\cdot}Al_2O_3{\cdot}3CaSO_4{\cdot}31.5H_2O$ ($7.5\ H_2O$); $3CaO{\cdot}Al_2O_3{\cdot}CaSO_4{\cdot}12H_2O$ ($6.5H_2O$); $3CaO{\cdot}Al_2O_3{\cdot}CaX_2{\cdot}10H_2O$ ($6H_2O$); $4CaO{\cdot}Al_2O_3{\cdot}Ca(IO_3)_2{\cdot}22H_2O$; $5CaO{\cdot}Al_2O_3{\cdot}Ca(IO_3)_2{\cdot}33H_2O$ with X for Cl, Br, I, NO_3, or ClO_3. Numerous photomicrographs and mineralogical characteristics are given. F. makes a hypothesis concerning chemical structure. For Part I see *Ceram. Abs.*, **14** [8] 181 (1935). F.E.V.

Classification and definition of hydraulic bonds. L. P. *Rev. gén. Sci.*, **45** [14] 421 (1934).—Whatever the manufacturing process, hydraulic bonds may be classified according to their setting and hardening properties. Some materials are listed and briefly described. General considerations are given on the evolution of the manufacturing processes of lime and cements. R.W.D.

Dependence of shrinkage of Portland cement on chemical and physical effects. HANS KÜHL AND DZUNG-HSIEN LU. *Tonind.-Ztg.*, **59** [70] 843–45; [71] 864–66; [74] 913–15; [82] 1016–18; [83] 1028–29 (1935). M.V.C.

Electromolten cement. R. W. LEONHARDT. *Zement*, **24** [4] 49–52 (1935).—Quicklime and bauxite are melted in an arc furnace; an essential component is calcium aluminate (35 to 50% Al_2O_3). The content of Fe_2O_3 is much higher than usual (5 to 15%). Hardening is practically ended after 12 to 15 hr., mechanical resistance exceeding 500 kg./cm.^{2} Chemical resistance is rather good. For 1 long ton of cement, 0.7 to 0.8 ton of bauxite, 0.40 to 0.45 ton of quicklime, 7 to 8 kg. electrodes, and 700 to 800 kw.-hr. are required. L. describes a plant for a daily production of 60 tons. Electrodes are moved forward by hand or automatically by tension of arc. Illustrated. F.E.V.

Fineness of grinding and lime saturation of clinker. G. MUSSGNUG. *Zement*, **24** [1] 1–8 (1935).—Influence of fineness of grinding on lime saturation of clinker was investigated, raw materials being variable. Determination of free lime is admittedly the surest way of proceeding. If raw materials differ widely from each other in chemical composition, fineness is important. The percentages of fluxes and brownmillerite in the batch are much more important than fineness of grinding. Blast-furnace slags mixed with some fluxes during firing show more chemical activity than natural clayey raw materials under the same conditions. It is possible to use relatively high contents of slag without danger of expansion. F.E.V.

Formation of crystallized hydrates of calcium silicates. WILHELM KÖHLER. *Tonind.-Ztg.*, **59** [62] 739–40; [63] 754–56 (1935).—A detailed discussion of researches on hydrates of calcium silicates and their effect on hardening of Portland cement is given. Experiments of K. showed that (1) wollastonite does not change when subjected to hydrothermal treatment; (2) dicalcium silicate and tricalcium silicate yield hillebrandite and a mixture of hillebrandite and calcium hydroxide, respectively, when treated in the same way. Tables, diagrams, and a literature index are given. M.V.C.

"Meta-alite," a metastable state of alite. S. SOLACOLU. *Zement*, **23** [40] 587–90 (1934); abstracted in *Referat. Silikatliteratur*, No. 1083 (1934).—Alite consists of tricalcium silicate and dissociates in the solid state at 1900° and into β-dicalcium silicate and lime at 1400°. The maximum of dissociation is reached at 1275°C. Alite is stable between 1400 and 1900°. Experiments with synthetically produced tricalcium silicate heated to 1900° are described. M.V.C.

Microstructures of some calcium aluminate melts. D. S. BELYANKIN AND N. A. TOROPOV. *Zentr. Mineral. Geol. A*, pp. 174–82 (1935).—Various Al_2O_3 slags from electric- and blast-furnace production were studied. The composition of the slags, the properties of the calcium aluminates and silicates crystallized, and the order of

crystallization of the different compounds in melts of different compositions are given. Illustrated with photomicrographs. H.I.

Possibilities of pozzuolanas in mortars and concretes. E. W. Scripture, Jr. *Eng. News-Rec.*, **115** [17] 563–67 (1935).—Chemically active materials of natural, treated, or artificial origin, adaptable as a cement blend or as a concrete admixture, are available to the engineer to serve in the rôle of "lime-fixer" for the cement, reducing susceptibility to corrosion and weathering and in some cases permitting a reduction in water-cement ratio with a paradoxical improvement of workability, thus reducing volume change and enhancing durability. The advantages and the pitfalls that accompany the use of pozzuolanas are analyzed. G.R.S.

BOOK

Researches on calcium aluminate combinations with calcium salts (Recherches sur les combinaisons entre les sels de calcium et les aluminates de calcium). Thése de doctorat en Sciences Physiques. Jeanne Foret. Hermann, Paris, 1935. F. studies the hydration of calcium aluminates in the presence of either lime or calcium salts, determines the definite compounds resulting from these reactions, and confirms the existence of isotropic tricalcium aluminate and of hexagonal tetracalcium aluminate. According to their respective degree of solubility in water, calcium salts exert different action on calcium aluminates. Conclusions of practical interest to the cement industry are also mentioned in the thesis. R.W.D.

PATENTS

Manufacture of cement. C. H. Breerwood (Valley Forge Cement Co.). U. S. 2,021,623, Nov. 19, 1935 (March 17, 1934).

Sorel-cement product and method of making. H. S. Lukens (Magnesium Cement Laboratories, Inc.). U. S. 19,779, Dec. 3, 1935; reissue of original 1,724,945, Aug. 20, 1929. The process comprises mixing a separately prepared emulsion of bituminous materials with a mixture of calcined magnesite, magnesium chloride, and a filler.

Enamel

Advantages of new equipment and control in economical porcelain-enamel plant operation. Harry Ingersoll. *Better Enameling*, **6** [10] 7–9 (1935).—The recently completed modernization of the Caloric Gas Stove Works plant at Topton, Pa., is described, and many benefits resulting from the installation of a complete process control system are enumerated. E.J.V.

Antimony (from enamels) in foodstuffs. T. McLachlan and D. M. Matthews. *Food Manufacture*, **10**, 325–27 (Sept., 1935).—In 1928 an outbreak of Sb poisoning occurred in England, due to the use of enameled vessels for making lemonade. The lemonade contained 10 gr. Sb per gallon. Other cases have occurred more recently, and the British Ministry of Health has put forward suggestions that the use of Sb in hollow-ware should be (*a*) prohibited, (*b*) allowed only as Sb_2O_3 or its compounds, or (*c*) allowed only on goods which are definitely labelled when sold. H.H.S.

Applying wet-process ground-coat enamels. Anon. *Better Enameling*, **6** [10] 20–21 (1935).—Wet-process cast-iron ground coat is applied by spraying, while sheet-metal ground coat is applied by dipping and draining or slushing. Reasons for these methods are given. Equipment used is listed, and the weight tests used to check proper enamel consistency and coating on the ware are described. E.J.V.

Breaking off of majolica enamels. Anon. *Glashütte*, **65** [36] 564–66 (1935).—Cast iron of a ferritic texture and having a cubic expansion of 316×10^{-7} was coated with a ground enamel at 780°, a white intermediary enamel at 740°, and a majolica enamel at 700°. The enamel began bursting after some time, reaching the metal surface. The coefficient of expansion of the majolica enamel was 309×10^{-7}, and that of the white enamel 314×10^{-7}. When boric acid was replaced by alkalis, the expansion of the enamel was increased and cracks were formed. The examination of the cast iron (fired at 800°) in the injured places showed brown spots containing up to 1.9% sulfur, while the average content of the cast iron was 0.085%. In such cases it is necessary to fire the cast iron to 850° and clean it with a sand blast. Illustrated. M.V.C.

Centrifugal method of cleaning castings. Martin H. Kidder. *Better Enameling*, **6** [11] 14–18 (1935).—A new system of cleaning castings is a mechanical, airless, abrasive method developed by the American Foundry Equipment Co. of Mishawaka, Ind. Pertinent information about this method is presented. Illustrated. E.J.V.

Design problems for vitreous enameled ware. H. L. Van Doren. *Ceram. Forum*, **2** [1] 2 (1935).—The versatility of vitreous enamels and some of the difficulties encountered through this versatility are discussed. Enamels have found their greatest adoption as a wear-resistant coating, but it is hoped that vitreous enamels will be more extensively used in the fields of architecture and decoration. M.C.S.

Drying and firing ground-coat wet-process enamel. Anon. *Better Enameling*, **6** [11] 19–20 (1935).—Various methods of drying ground-coat enamels are listed. Brushing and black edging of ware is described. Ground-coat enamels are fired at temperatures of 1550 to 1600°F on sheet metal, while cast-iron ground coats are usually made to meet specific requirements and their firing temperatures vary for this reason. Necessary equipment is listed. E.J.V.

Effect of copper in malleable iron. C. H. Lorig and C. S. Smith. *Trans. Amer. Foundrymen's Assn.*, **6** [1] 211–36 (1935).—Experiments with copper-bearing malleable iron have shown that it has certain advantages over ordinary unalloyed malleable cast iron. Copper was found to be easily soluble, either with the charge or in the ladle, and at least 3% goes into solution. Less than 0.50% copper has little effect on the physical properties, but from 0.70 to 1.25 or 1.50% improved the endurance strength. The mechanical properties of iron containing more than 0.70% copper are improved by precipitation hardening.

Copper does not change the fluidity or shrinkage of malleable iron or increase cracking. It has no marked influence on the structure. Copper accelerates graphitization considerably, both in the first and second stages. It reduces the susceptibility to intergranular embrittlement. H.E.S.

Experiments on internal strain in simple welded joints. F. BOLLENRATH. *Arch. Eisenhüttenwesen*, 9, 203–207 (1935).—Internal strain was determined by the deformation of drilled holes and by the change in length of a strip cut out from the joint. Various welding methods were compared. X-shaped joints gave better results for heavy plates than V-shaped joints. W.M.C.

Furnace atmosphere. ANON. *Better Enameling*, 6 [9] 13–14 (1935).—A discussion of theory and case histories regarding the effect of furnace atmospheres on porcelain enameled ware points to the importance of giving consideration to furnace atmosphere regardless of the type of furnace. The comparatively simple CO_2 test provides a method of periodical check-up in fuel-fired furnaces. Occasional inspection of muffles, stacks, and dampers is always a worth-while precaution, as is a check-up on venting for the electrically fired furnace. E.J.V.

Gas-fired radiant tubes in porcelain enameling. E. F. GEHRIG. *Ind. Heating*, 2 [11] 645–48 (1935).—Instead of firing the furnace with gas directly and placing the goods in a muffle, the gas is burned through hairpin-shaped tubes with a luminous flame over the whole length of the tube under a slightly negative pressure so that no discharge of combustion gases into the working chamber of the furnace can occur. Maximum temperatures inside the tube wall do not exceed 1800°F, which is sufficient to produce a furnace or outside wall temperature of 1600°F. The advantages are a strictly oxidizing atmosphere (a prime requirement for good enameling results), less waste in production, less fuel consumption, and easy repair. Operating data are given. M.H.

How the continuous enameling furnace affects copperheads. H. L. COOK. *Bull. Amer. Ceram. Soc.*, 14 [12] 393–95 (1935).

Induction heating in automotive production. E. L. BAILEY. *S. A. E. Jour.*, 37, 422–24 (1935).—The use of inductive heating for firing lacquered parts at 160°F and for melting and heat treating steel is discussed. The lacquer on thin sheet material is dried ideally in that the film is heated on the inside next to the metal and gradually dried from the inside to the outside. W.H.B.

EDITORIAL NOTE: This idea is worth consideration by enamelers.—R.C.P.

Measuring specific heat of steel at elevated temperatures. K. MELISS. *Arch. Eisenhüttenwesen*, 9, 209–12 (1935).—A water calorimeter was used in the measurements. High accuracy is obtainable by this method both for direct and comparison experiments. It is proposed to use sintered corundum as a standard material for specific-heat determinations. W.M.C.

Milling the enamel. ANON. *Better Enameling*, 6 [9] 18–19 (1935).—Milling of enamels, an operation in which raw frit is converted into a suspended state, requires careful control. Porcelain-lined mills are used. The equipment, other than the mills, is listed. The charging of the mills, grinding, testing for fineness and screening the milled enamel, storage, and care of the mills are discussed. Illustrated. E.J.V.

Mixing and melting enamel. C. A. OTTERSBACH. *Glashütte*, 65 [33] 520–21 (1935).—Directions for the working of raw materials, their mixing, and the firing of enamel are given. Various types of furnaces are described. The melting temperature varies between 800 and 1000°C. An overmelted white enamel becomes translucent, has a vitreous appearance, and has needle tappings. M.V.C.

Permanent mold castings. F. J. WALLS. *Trans. Amer. Foundrymen's Assn.*, 6 [2] 427–48 (1935).—The history of attempts to make permanent molds is almost as old as the art of casting metals. W. describes the development of the present permanent mold machines. In discussing this subject he comments on fundamentals of mold design, stressing the point that it is the controlling factor in mold life. One of the most important problems in the successful production of permanent mold castings is the balancing of pouring and cooling times. By means of a chart, W. shows that permanent mold castings are divided into four types. Melting practice and the structure and properties of the irons obtained are discussed. W. also gives a short résumé of what has been done in the casting of alloy irons in permanent molds and outlines the trends in the development of that process of metal casting. H.E.S.

Pickling plant and equipment. HENRY WIGGIN & CO., LTD. *Metal Ind.* [London], 47, 233–34 (1935).—The principal properties of material used in the fabrication of a pickling plant are high strength, rigidity, and resistance to corrosion by acid, steam, or alkalis. These requirements are satisfactorily fulfilled by Monel metal. H.E.S.

Pickling problems. MIDLAND METALLURGICAL SOCIETY. *Metal Ind.* [London], 46, 215–17, 247–49 (1935).—The following problems encountered in the pickling of iron and steel are discussed: (1) correlation of principal factors involved in pickling, (2) acid recovery, (3) surface pickling, (4) construction of pickling vats, (5) washing after pickling, (6) phosphoric acid pickling, (7) pickling with solutions containing lead, (8) inhibitors, (9) continuous pickling, (10) temperature control, and (11) mechanical pickling. Some aspects of the pickling of nonferrous metals are also given. H.E.S.

Priest-Lange reflectometer applied to nearly white porcelain enamels. IRWIN G. PRIEST. *Jour. Research Nat. Bur. Stand.*, 15 [5] 529–50 (1935); R.P. 847. Price 5¢.—The Priest-Lange reflectometer is described in detail and the theory of its use is given for determining relative apparent reflectance for various spectral distributions of illumination. A method for measuring spectral selectivity of reflectance is also described together with a method for measuring diffuse-plus-specular reflectance as distinguished from diffuse reflectance alone for perfectly polished specimens. The application of the instrument to porcelain enamel samples is illustrated by a detailed account of measurements made on seven typical samples. The method for measuring diffuse-plus-specular reflectance as distinguished from diffuse reflectance is shown to be inapplicable to enamel samples because of their optical imperfections, but measurements of spectral selectivity are shown to give results in close correlation with the colors of the samples observed directly. R.A.H.

Research laboratory finished in vitreous enamel. GEORGE P. MACKNIGHT. *Bull. Amer. Ceram. Soc.*, **14** [12] 404–406 (1935).

Thickness gage in porcelain enameling. H. H. HOLSCHER. *Better Enameling*, **6** [10] 16–17 (1935).—Three methods of measuring enamel thickness are described, the magnetic gage giving the greatest accuracy. The chipping of enamel is dependent to a great extent upon the coating; therefore accurate measurements of thickness are important in solving enamel problems. Color is also affected by enamel thickness. Uniformity of spraying can be checked by use of the thickness gage. The measurement of the beaded edge thickness is also possible. E.J.V.

Valuation of clay for enameling. L. VIELHABER. *Emailwaren-Ind.*, **12** [34] 273–75 (1935).—The properties required of clay for enamels are discussed, and studies to determine the behavior and effect of clay in enamels are dealt with. The ratio of alumina to silica in clay is not determinative. Tests with deposits do not show the suspending power of the enamel and are not comparable as the amount of water used is unknown and the varying quantity of alkalis from the enamel when dissolved changes the results. The effect of alkalis may be considered to be constant, however, in ordinary enamels, and the clay can be evaluated according to the way it deposits alone. Experiments with various German clays are described. M.V.C.

Welding methods. C. H. DAVY. *Welding Jour.*, **32**, 298–300, 309–10 (1935).—A general account of papers read before the Institution of Chemical Engineers is given. D. considers arc welding to offer few more advantages than acetylene, but for plates $^1/_2$ to $^3/_4$ in. thick joined in butt welding the arc gives lower cost. Not enough fatigue and corrosion data have been accumulated to predict the safety of the method for fabricating high-temperature, high-pressure equipment. For joining tubes the resistance butt weld is considered superior because no addition of metal from outside source is necessary, but for large tubes the necessary kv.-a. capacity is increased to extremes. It is therefore restricted to tubes with a maximum cross-sectional area to be welded of 30 in.^{2} Atomic H welding is considered supplementary to metal arc and not competitive; it is also considered unsuitable for material greater than $^1/_2$ in. thick but is advantageous with thin sheets of stainless steels and thin Al or dural, using a flux. W.H.B.

PATENTS

Enamelware. J. E. ROSENBERG (O. Hommel Co.). U. S. 2,022,434, Nov. 26, 1935 (Jan. 22, 1935). The method herein described of enameling a steel article consists in applying to the surface to be enameled an ammoniacal solution of a cobalt compound, evaporating the applied solution with the escape of ammonia and the consequent precipitation of cobalt hydroxide insoluble in water in the absence of ammonia, covering the so-coated surface with a slip of prepared enamel rendered fluid by water, drying, and firing the so-prepared material.

Percolator top. W. B. MOORE AND J. L. WAHL (Moore Enameling and Mfg. Co.). U. S. 2,022,320, Nov. 26, 1935 (April 6, 1935).

Production of articles having a multicolor finish. FRANZ NOWAK (Porcelain Enamel & Mfg. Co.). U. S. 2,021,820, Nov. 19, 1935 (May 6, 1931).

Production of porcelain enameled articles of changeable color. R. H. TÜRK (Porcelain Enamel & Mfg. Co.). U. S. 2,021,819, Nov. 19, 1935 (March 13, 1931).

Glass

Accelerated drawing of glass by the Fourcault method. I. I. KITAIGORODSKIĬ. *Keram. i Steklo*, **11** [7] 3–7 (1935).—The chief defects in the Fourcault glass produced in U.S.S.R. are its low chemical resistance, great striation, and the presence of various inclusions, such as stones, crystalline formations, and bubbles. These defects are due chiefly to an incorrect composition of the glass. The latest researches in Europe and U.S. dealing with the composition, melting, coloring, and cooling of glass are briefly discussed, and the results of studies made by the Russian Institute of Glass are analyzed. The main conclusions are as follows: (1) A coarse-grained batch melts much more slowly than a fine-grained batch; (2) during the melting of such a batch, the process of glass formation occurs very rapidly. Constructional details to improve Fourcault machines are dealt with. M.V.C.

Action of glue and cement on glass. OTTO HERFURTH. *Diamant*, **57** [16] 181–82 (1935).—The adherence of glues and cements on glass is discussed in detail. Glue and cement must be adapted to glass, and it is important that their reaction on glass be determined. M.V.C.

Chemical action of potassium nitrate during glassmelting. O. KNAPP. *Keram. Rundschau*, **43** [20] 227–29 (1935).—It is an open question whether potassium nitrate acts as a refining agent. K. made different tests with a batch containing 12.9 g. sand, 3.63 g. limestone, and 4.18 g. potassium nitrate progressively heated in a crucible electric furnace. After each firing at 300°C, 400°C, etc., a complete analysis of soluble and insoluble components was made. Between 600° and 800°C, decomposition of nitrate was completed. There was a transitory appearance of KNO_2 between 400° and 800°C. Decomposition of $CaCO_3$ takes place at 500 to 800°C. Above 800°C there is no chemical action evolving gas. Formation of calcium silicate begins below 700°C, and that of potassium silicate below 800°C. There is no doubt that KNO_3 by itself has no refining power. In the presence of As_2O_3 or Sb_2O_3 its action seems *a priori* very doubtful. F.E.V.

Chemical properties of glass. GEORGE W. MOREY. *Can. Chem. Met.*, **19** [11] 293 (1935).—The earliest artificial glasses were essentially of the same composition as the common soda-lime-silica glasses of today, but contained too much alkali to have the highest chemical resistance. Lime is the stabilizer usually employed to produce a glass suitable for ordinary purposes. Too much silica raises the melting point and causes easy devitrification, excess lime causes wollastonite crystallization and raises the melting point, and excess alkali results in susceptibility to solution or attack by water. Potash-lime-silica glasses are more viscous than soda glasses. Crystallization of laboratory ware is a surface phenomenon, resulting from excess silica, following removal

of some sodium carbonate from the glass due to action of absorbed water. Changes in the coefficient of expansion and electrical conductivity of glass take place at about 500°C. X-ray pictures of soda-lime-silica glasses show the characteristic ring pattern associated with liquids, with the addition of certain bands thought to be due to separating crystallites. E.J.V.

Commercial importance of furnace design. W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **19** [75] 184–99*P* (1935).—Modern tank furnaces show a tendency to be smaller due to the increased efficiency of melting and the advantages of keeping a practically constant load on the furnace. The figure of 9 to 12 sq. ft. of melting area per ton of glass is not uncommon for glass bottle furnaces operated by automatic machines, and 3 to 4 sq. ft. per ton is obtained when melting amber-colored glasses. The size of pot furnaces has increased, and recuperative furnaces accommodating 12 pots are now worked. There appears to be no definite relationship between the ratio of melting area and refining area in tank furnaces. The insulation of furnaces is considered. Data show that air cooling of the side blocks of a tank furnace accounts for 14 to 18% of the total heat available from the coal fed into the producer. The question as to whether or not the insulation of the blocks seriously diminishes the furnace melting efficiency is of importance. The rate of melting and the choice of fuel are essentially economic considerations. A discussion is included. A.A.

Constitution and color of glasses containing iron and manganese oxides. W. E. S. TURNER AND W. WEYL. *Jour. Soc. Glass Tech.*, **19** [75] 208–16 (1935).—A spectroscopic study of glasses containing iron and manganese oxides, both separately and together, showed that the MnO in a manganese glass caused only faint coloration. The per cent of Mn_2O_3 increased with increasing manganese concentration, but was always small compared to the per cent of MnO. Mn_2O_3 was very easily reduced by FeO to MnO. Glasses containing up to 2% iron oxide and 4 to 5% manganese oxide were relatively transparent. It was concluded that the bluish-green FeO had reduced the purple Mn_2O_3 to the relatively colorless MnO with the formation of the golden-brown and more transparent Fe_2O_3. The ultimate color of iron oxide-manganese oxide-containing glasses depended on the total ferric oxide and manganous oxide present. The colors produced by oxides and salts of manganese in aqueous hydrochloric acid and vitreous solutions, as well as in organic solvents, were considered in conjunction with the above. Illustrated. A.A.

Durability of quartz glass ignition vessels. M. A. BESBORODOV AND T. A. LADE. *Jour. Soc. Glass Tech.*, **19** [75] 217–20 (1935).—Transparent quartz glass vessels were used for the ignition of different precipitates employed in quantitative chemical analysis. The quartz glass showed greatest resistance to $MgSO_4$, KNO_3, nickel dimethylglyoxime, a mixture of 10% $Al(OH)_3$ and 90% $Fe(OH)_3$, K_2PtCl_6, and a mixture of 50% NaCl and 50% KCl. The greatest corrosion occurred with $PbSO_4$, $ZnNH_4PO_4$, $ZnCO_3$, and SnO_2, especially with the first. The use of quartz vessels could be recommended in quantitative analysis involving all the reagents enumerated with the exception of the above four. A mixture of 90% $Al(OH)_3$ and 10% $Fe(OH)_3$ showed a corrosivity comparable to that of $ZnCO_3$. Numerical data are given. A.A.

Effect of storage on the chemical durability of glass containers. V. DIMBLEBY, H. S. Y. GILL, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **19** [75] 231–43 (1935).—Examination of the durability of 4-oz. medicine bottles of different makes and composition but of the same shape, using as a basis of comparison the standard test of the Society of Glass Technology, showed that storage conditions (humidity, temperature, atmosphere, and prewashing) exercise considerable influence on the glass surface, both visibly and as measured by alkali-extraction data. The inside surface of the bottles was alkaline, most strongly so when the bottle had been stoppered. The outside surface of the bottle was acidic. Storage was found to improve the durability of initially good bottles only; washing prior to storage and boiling with water improved the durability of both the good and the poor bottles. The stoppered bottles always had a higher durability after storage than the open-mouthed bottles. Visible effects of surface change usually appeared as the weathering pattern known as "spider's web." See also "Corrosion—" *Ceram. Abs.*, **14** [2] 33 (1935). A.A.

Effect of temperature on the resistance of bottles. K. H. BORCHARD AND H. H. ACHMED. *Glashütte*, **65** [35] 547–49(1935).—Experiments with dark bottles showed that their resistance diminishes about 15% per degree on heating. The resistance of light green bottles, of the same composition, for pasteurizing decreased 13% between 23 and 71°C. Resistance to thermal shock by heating from 28 to 80° yielded a breakage of 23%. Progressive heating reduces breaking to 0. Bottles to be pasteurized, which are subjected to noticeable pressures, have their resistance diminished because of the increase in temperature even with progressive heating as is the case in practice. M.V.C.

Electron diffraction by vitreous silica powder. N. A. SHISHACOV. *Nature*, **136** [3439] 514 (1935).—Powdered vitreous silica glass does not give sharp rings when X-rayed using a wave-length of 1.54Å. S. obtained sharp rings up to 10 or more in number by electron diffraction using a wave-length of 0.06Å. He gives their Bragg spacings and interprets his results as indicating a scattering by tetragonal cristobalite crystallites. Axial ratio is 1.06; $a = 6.87$; $c = 7.28$. The size of these crystallites which make up the silica glass is probably about 15 to 20Å. J.L.G.

Gem glass. RUDOLF HOHLBAUM. *Glashütte*, **65** [27] 407–409; [28] 420–22; [29] 435–37; [30] 456–57; [31] 469–71; [34] 531–33 (1935).—A comprehensive and detailed description is given of the production of imitation gem glass. This glass is manufactured in small plants and the methods of production and composition are kept secret. The manufacture consists of (1) production of the basic or "composed" glass, (2) its grinding, and (3) working the polished glass so that it will be similar to gems. These are described. The basic glass or "strass" (the name of a famous jeweller from Nürnberg of the 17th century) is a glass with a high lead content or is free from lead but contains boric acid. This glass is colored with metallic oxides. An account of the obtaining of imitation dia-

monds, topazes, rubies, emeralds, sapphires, amethysts, aquamarines, garnets, and opals is given. M.V.C.

Glass an accompaniment to flowers and wine. C. G. Holme. *Studio*, **110** [509] 84–85 (1935).—Six photos of table arrangements exhibited at the 4th Glass Convention held at Folkestone, England, are shown. H.H.S.

Glass building block. Corning Glass Works. *Amer. Glass Rev.*, **54** [51] 19 (1935).—The Pyrex-brand building block is of clear glass, is $11^3/_4$ x $11^3/_4$ x 4 inches, weighs ten pounds, is intended for interior and exterior constructions, has a coefficient of expansion of 0.0000032, and will withstand sudden temperature changes. The block is partially evacuated and has a strength far greater than most blocks. M.C.S.

Glass mosaic. W. H. *Diamant*, **57** [23] 273 (1935).—The use of glass mosaics for interior decoration in buildings is discussed and their production briefly described. M.V.C.

Glass reports. Anon. *Glashütte*, **65** [35] 549–51; [36] 566–68; [40] 626–29; [42] 654–57 (1935).—A series of studies dealing with the analysis of glass, its coloring and decoloration, raw materials, glassmelting, testing, defects, furnaces, refractories, and glassworking is given. M.V.C.

Glass yarn. Owens-Illinois Glass Co. *Amer. Glass Rev.*, **55** [6] 9 (1935).—Glass yarn recently developed may be woven or knit into pieces of wearing apparel, draperies, and awnings and in such applications may find interesting adoptions. M.C.S.

Glues and cements for glass. Otto Herfurth. *Diamant*, **57** [18] 213; [19] 221–22 (1935).—The composition and directions for use of glass glues and cements are given. M.V.C.

Heat-absorbing glass windows. W. W. Shaver. *Heating, Piping & Air-Conditioning*, **7** [9] 447–51 (1935).—Sunlight energy coming through ordinary glass windows constitutes a large percentage of the total cooling load on the refrigeration equipment controlling the room temperature. This load can be reduced by using a heat-absorbing clear glass. Test results on an ordinary window glass and a heat-absorbing glass built into identical test houses on the roof of a four-story factory building at Corning are given and explained. A reduction in cooling load of from 9 to 28.5% was secured with the heat-absorbing heat-resistant glass in the outside sash of a window with ordinary glass in the inside sash and a reduction of from 16 to 24% with single heat-absorbing glass. Because of the heating of the absorbing glass from the sun's energy the low coefficient of thermal expansion of the borosilicate-absorbing glass used provides an added factor of mechanical safety.

Glass	Thickness	Visible light transmission	Total solar transmission	Total solar energy reflection
Borosilicate heat-absorbing	3 mm.	76%	42%	5%
Ordinary window double-strength	3 mm.	92%	88%	8%

J.L.G.

Hygienic glass for sanitoriums. J. Polivka. *Tscheco-Verre*, **1** [4–5] 83–86 (1934); abstracted in *Referat. Silikatliteratur*, No. 1327 (1935).—Glasses permeable to ultra-violet rays and those absorbing infra-red rays are discussed and their properties are given. M.V.C.

Increase in efficiency of Fourcault machines at the Chernyatinskiĭ glassworks. Anon. *Keram. i Steklo*, **11** [7] 13–20 (1935).—Improvements obtained in Fourcault glass manufactured at the Chernyatinskiĭ glassworks are described. M.V.C.

Knowledge of glass defects. Otto Herfurth. *Diamant*, **57** [10] 109–11; [15] 169–70 (1935).—Defects due to faulty composition, working, and treatment of the glass are analyzed. M.V.C.

Machine age. G. L. Pilkington. *Jour. Soc. Glass Tech.*, **19** [75] 106–19*P* (1935).—P., in his presidential address to the Fourth Glass Convention, discusses mechanization and its effect upon the glass industry, touching the subjects of employment in the industry, quality and design of the products, and propaganda for the industry. A discussion is included. A.A.

Manufacture of toughened glass in Australia. Lord Cozens-Hardy. *Sydney Morning Herald*, Oct. 30, 1935.—Pilkington's factory at Adelaide (S. A.) is the first in Australia to produce toughened glass suitable for use in motorcars. H.H.S.

Manufacturing glass cotton. Drep. *Allgem. Glas- & Keram. Ind.*, **25** [1] 3 (1934).—It is reported that glass cotton has been successfully produced in an apparatus similar to a metal-spraying device. On account of its high viscosity, glass, when treated in the apparatus, can not be pulverized but is turned to very fine threads. This method of manufacturing glass cotton will be soon practiced industrially. R.W.D.

Mass production of glass novelties at plant of L. E. Smith Glass Company. J. B. Nealey. *Ceram. Age*, **25** [4] 123–25 (1935). F.G.H.

Measuring temperature during enameling and its application in practice. Oskar Kerstan. *Glashütte*, **65** [33] 517–20; [34] 535–37 (1935).—The advantages of controlling temperatures by means of automatic recording apparatus is pointed out. The temperature should be measured continuously in enamel ovens, muffle kilns, smoke in the flue pipes, and drying ovens. The temperature of the air-steam for gas generators, that leaving the burner and that entering it, should be measured from time to time. The control of the chemical composition of gas and flues, pressure in the gas collector, and steam and air pressure is very important. Diagrams are given and analyzed, and defects due to excessive or insufficient firing are dealt with. M.V.C.

Melting glass with dust-like sand. A. N. Dauvalter. *Keram. i Steklo*, **11** [8] 15–18 (1935).—Comparative experiments made with various kinds of sand used for melting glass are described. Glass melted with dust-like sand was of higher quality than that melted with ordinary sand. Tables show the results. M.V.C.

Miller machine for producing plate glass. A. Kh. Miller and N. P. Korotkov. *Keram. i Steklo*, **11** [8] 18–26 (1935).—Details of construction and operation are given. M.V.C.

Not just glass. P. H. Smith. *Sci. Amer.*, **153** [6] 314–17 (1935).—A brief survey of the progress in glassmaking,

from 6000 years ago until today, is presented. Different types of glasses and their use are discussed. Illustrated. W.M.C.

Official definition of sheet glass. ANON. *Glaces et Verres*, 8 [43] 2 (1935).—The Board of Syndics of the French Plate- and Sheet-Glass Manufacturer's Assn., considering that the terms "glace" and "verre" are often misused, and in order to suppress confusion which may lead to fraudulent abuses detrimental to customers and also to facilitate custom taxation, freight charge, or insurance fee computation and make this adequate to the kind of goods referred to, has officially adopted the following definitions: "Glace" (plate glass) is a transparent product, obtained in the rough state by casting, rolling, etc., which has undergone, after annealing, a complementary grinding and polishing mechanical treatment that renders both of its surfaces glossy, parallel, and plane. "Verre" (window glass, sheet glass) is a transparent product, obtained by blowing or drawing processes, which, after cooling off, is not submitted to any surface treatment. It is a rough product, annealed but not surfaced. These definitions should be referred to in case of disagreement as to the nature of glass sheets used either for glazing purposes or in decorative motifs. R.W.D.

Packing and storing glass. O. HERFURTH. *Diamant*, 57 [20] 233–35; [22] 257–59 (1935).—Directions are given. M.V.C.

Phonolite. E. DOBROVSKY. *Allgem. Glas- & Keram. Ind.*, 26 [10] 1 (1935).—Phonolite is an eruptive mineral containing a high percentage of alkaline oxides. All bottle glassworks use it considerably. A description and the chemical composition of Bohemian phonolites are given. R.W.D.

Rational working conditions for Fourcault machines. N. C. BREGMAN. *Keram. i Steklo*, 11 [8] 7–15 (1935).—Results of experiments made at the Gomel Glass Works are discussed. M.V.C.

Sand for glassmelting. ANON. *Glashütte*, 65 [33] 507–11 (1935).—The German deposits of quartz and clay sands, their working, and a project for testing them are described. Bibliography. M.V.C.

Scratch hardness of toughened plate glass. A. J. HOLLAND AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, 19 [75] 221–30 (1935).—An examination of the scratches or cuts produced on both ordinary plate glass and on toughened (armor-plate type) glass was made using (1) a conically ground and polished diamond, (2) a cutting diamond, (3) a cutting wheel (tungsten alloy steel) under a constant load and with uniform velocity, and also (4) a cutting diamond and (5) a cutting wheel drawn by hand. Under the same cutting conditions, the width of scratch was nearly the same for plate as for toughened glass, but with the latter the cut was cleaner, and after an interval of time, dependent on the cutting load, the sides of the cut underwent splintering. The tensile stress at the center of the sheet was calculated from the curvature measurements of the glass splinters produced and varied from 1.0 to 5.3 $\times$ 10^4 kg./cm.^{2} Specimens of toughened plate glass, although badly scratched on both surfaces, broke with the characteristic fracture under the ball impact test. Numerical data and photomicrographs are given. A.A.

Small tank furnaces. R. HOHLBAUM. *Sprechsaal*, 68 [38] 584–87 (1935).—Small tank furnaces may be used sometimes to great advantage, even with a production of 500 kg. in 24 hr. Such furnaces may be used for successive meltings of different glasses. Simultaneous fusions were realized when the tanks were divided into separate compartments. These small tank furnaces are especially suitable for special glasses which corrode refractories severely. Details of construction and operation are given. M.V.C.

Sources of defects when melting glass in tank furnaces. ANON. *Glashütte*, 65 [34] 537–38 (1935).—The importance of determining the causes of the appearance of streaks and striae when melting glass in tank furnaces is pointed out, and cases from practice are briefly discussed. M.V.C.

Standards for safety glass. ANON. *Diamant*, 57 [11] 121–24 (1935).—German standards specifications for various types of safety glass are discussed. M.V.C.

Survey of furnace temperatures of a glass-tank melting furnace. H. S. Y. GILL AND N. A. NICHOLS. *Jour. Soc. Glass Tech.*, 19 [75] 189–207 (1935).—The results are recorded of measurements of the surface temperature of the structure throughout the operating life of a gas-fired tank of 50 tons dead-weight capacity and having a melting area of 135 sq. ft. An attempt was made to correlate the progressive changes in surface temperature with changes in the tank-block thickness due to corrosion and with other variable conditions, internal and external. The external temperature of the blocks, as indicated by a surface pyrometer, was a guide to the extent of the block corrosion and indicated where extra cooling air was necessary in order to prolong the life of the furnace. A spot on the crown, which when not insulated had a temperature of 250°, on insulation was raised to 900°. Illustrated. A.A.

BOOK

Geometrical Optics and Photometry (Optique et Photométrie dites géométriques). H. BOUASSE. 620 pp. Delagrave, Paris, 1934. This book is a new edition of a previous one entitled "Optique géométrique élémentaire," published in 1917. The following main subjects are treated: mirrors, dioptrics, achromatism, and photometry. The reader will find in this text-book an accumulation of scientific data. R. W. DEVILLERS

PATENTS

Apparatus for:

Feeding glass. E. E. SLICK, JR. U. S. 2,021,523, Nov. 19, 1935 (July 5, 1933).

Handling glassware. J. C. E. SCHWAB (Hazel-Atlas Glass Co.). U. S. 2,022,786, Dec. 3, 1935 (June 27, 1933).

Making sheet glass. K. G. KUTCHKA (Pittsburgh Plate Glass Co.). U. S. 2,021,186, Nov. 19, 1935 (Feb. 16, 1935).

Producing laminated glass. G. B. WATKINS (Libbey-Owens-Ford Glass Co.). U. S. 2,022,484, Nov. 26, 1935 (May 21, 1930).

Treating molten material. OSKAR BLUME. U. S. 2,022,755, Dec. 3, 1935 (Nov. 21, 1934).

Turning plate glass. JOHN KRISTOF. U. S. 2,022,242, Nov. 26, 1935 (Feb. 11, 1935).

Use in cutting laminated glass. C. E. HESS (Libbey-Owens-Ford Glass Co.). U. S. 2,022,466, Nov. 26, 1935 (Jan. 21, 1932).

Bottle. JOSEPH PHILBRICK (Parsons Ammonia Co., Inc.,). U. S. 2,022,520, Nov. 26, 1935 (July 7, 1934).

Device for the continuous renewal of glass in a drawing-off basin attached to a glass furnace. EMILE ROIRANT (Soc. anon. d'études et de constructions d'appareils mécaniques pour la verrerie). U. S. 2,023,745, Dec. 10, 1935 (Feb. 3, 1934).

Form for bending glass. H. J. GALEY (Pittsburgh Plate Glass Co.). U. S. 2,021,180, Nov. 19, 1935 (Jan. 26, 1934).

Furnaces for melting glass. COMPAGNIE INTERNATIONALE POUR LA FABRICATION MÉCANIQUE DU VERRE (PROCÉDÉS LIBBEY-OWENS) SOC. ANON. Brit. 439,013, Dec. 11, 1935 (Sept. 8, 1934).

Glass articles provided with designs. ALEX KNEIP (Winthrop Chemical Co., Inc.). U. S. 2,023,175, Dec. 3, 1935 (June 30, 1933).

Glass-cutting machines. F. W. O. WERNICKE AND B. R. MÜLLER (trading as Wernicke & Co.). Brit. 437,840, Nov. 20, 1935 (Aug. 15, 1933).

Glass-handling apparatus. H. S. HEICHERT (Pittsburgh Plate Glass Co.). U. S. 2,021,183, Nov. 19, 1935 (Dec. 18, 1933).

Glass polisher. T. E. OBRIG (Gall & Lembke, Inc.). U. S. 2,024,303, Dec. 17, 1935 (Dec. 7, 1933).

Laminated decorative glass-surfaced sheets. E. W. ALDRIDGE. Brit. 438,268, Nov. 27, 1935 (Dec. 15, 1934).

Laminated glass. J. W. H. RANDALL (Libbey-Owens-Ford Glass Co.). U. S. 2,022,479, Nov. 26, 1935 (April 20, 1928).

Lens-grinding machine. L. L. HOUCHIN. U. S. 2,023,525, Dec. 10, 1935 (March 1, 1935).

Machine for edging glass sheets. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,021,198, Nov. 19, 1935 (Feb. 23, 1935).

Machine for forming glass lens blanks. A. N. CRAMER (Alice B. Cramer). U. S. 2,023,781, Dec. 10, 1935 (Sept. 28, 1931).

Machine for glazing glassware. C. W. DAVIS (Mantle Lamp Co. of America). U. S. 2,024,818, Dec. 17, 1935 (Feb. 27, 1931).

Machine for the manufacture of bottles, flagons, etc. EMILE ROIRANT (Soc. anon d'études et de constructions d'appareils mécaniques pour la verrerie). U. S. 2,021,670, Nov. 19, 1935 (Jan. 28, 1932).

Manufacture of laminated nonsplintering glass. ARCHIBALD RENFREW (Imperial Chemical Industries, Ltd.). U. S. 2,024,389, Dec. 17, 1935 (March 16, 1933).

Method and apparatus for bending glass sheets. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,021,197, Nov. 19, 1935 (March 9, 1934).

Method and apparatus for melting glass. W. O. AMSLER (Hartford-Empire Co.). U. S. 19,788, Dec. 17, 1935; reissue of original 1,889,510, Nov. 29, 1932.

Method and apparatus for shaping glass. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 437,909, Nov. 20, 1935 (Sept. 29, 1933).

Method of:

Cooling glass. G. V. MCCAULEY (Corning Glass Works). U. S. 2,022,215, Nov. 26, 1935 (Feb. 28, 1935).

Feeding molten glass. T. F. PEARSON. Brit. 439,150, Dec. 11, 1935 (April 23, 1934).

Making lenses. E. J. REH (Bausch & Lomb Optical Co.). U. S. 2,021,381, Nov. 19, 1935 (Jan. 13, 1934).

Making partitioned glass containers. C. G. HILGENBERG AND C. B. GARWOOD (Carr-Lowrey Glass Co.). U. S. 2,023,474, Dec. 10, 1935 (Dec. 27, 1932).

Making plungers for glass molds. R. W. LUCE (Eastman Kodak Co). U. S. 2,024,650, Dec. 17, 1935 (Feb. 21, 1933).

Manufacturing glassware and apparatus therefor. GILBERT SCHAFFER AND G. F. JARDINE (Hazel-Atlas Glass Co.). U. S. 2,024,748, Dec. 17, 1935 (Dec. 11, 1934). The method of blowing glass containers of noncircular cross-sectional shape comprises forming reservoirs of ductile glass in the interior of a circular parison and, while blowing the parison to its final noncircular form, drawing the ductile glass from the reservoirs in the directions the glass is blown the farthest.

Manufacturing moisture-resistant mineral wool. E. A. TOOHEY (Johns-Manville Corp.). U. S. 2,022,750, Dec. 3, 1935 (Dec. 24, 1929).

Marking glass. T. B. DRESCHER (Bausch & Lomb Optical Co.). U. S. 2,024,277, Dec. 17, 1935 (Oct. 27, 1932). A method of treating a glass surface comprises applying to the surface a substance comprising stannous chloride, amyl acetate, petrolatum, and hydrofluoric acid.

Method and means for surfacing glass. BERNARD LONG (Soc. anon. des manufactures des glaces et produits chimiques de Saint-Gobain, Chauny, et Cirey). U. S. 2,023,275, Dec. 3, 1935 (July 28, 1933).

Mineral wool and manufacture thereof. J. E. MORROW AND J. B. BARNITT (Aluminium Co. of America). U. S. 2,022,811, Dec. 3, 1935 (Nov. 19, 1931).

Neon tube and method of making. A. P. TALLMAN. U. S. 2,023,558, Dec. 10, 1935 (Dec. 17, 1934).

Ophthalmic lens. E. D. TILLYER (American Optical Co.). U. S. 2,023,907, Dec. 10, 1935 (Dec. 31, 1932). U. S. 2,024,552, Dec. 17, 1935 (Jan. 23, 1933).

Ophthalmic lens and method of making. SCOTT STERLING (Bausch & Lomb Optical Co.). U. S. 2,021,812, Nov. 19, 1935 (July 26, 1935).

Optical glass composition. M. R. SCOTT (Bausch & Lomb Optical Co.). U. S. 2,021,244, Nov. 19, 1935 (March 7, 1932). A colored optical glass has a refractive index between 1.50 and 1.55 and a dispersion, as expressed by ν, between 51.0 and 58.5 and comprises compounds of lead, manganese, and titanium.

Packing for bottles. FRANZ DEGEMEYER (Industry Issue and Finance Co., Ltd.). U. S. 2,023,518, Dec. 10, 1935 (Oct. 18, 1932).

Process for causing liquid slags and melts to set in a highly porous fashion. C. H. SCHOL. U. S. 2,024,308, Dec. 17, 1935 (June 14, 1932).

Process for making glass corner tile. G. F. MATTMAN (Cincinnati Advertising Products Co.). U. S. 2,024,775, Dec. 17, 1935 (Nov. 22, 1933).

Process for the manufacture of articles containing or consisting of silica, and articles produced thereby. Corning Glass Works. Brit. 438,782, Dec. 4, 1935 (Aug. 27, 1934).

Production of tempered glass sheets. Pilkington Bros., Ltd., and J. Wilson. Brit. 437,123, Nov. 6, 1935 (April 28, 1934).

Puttyless glass roof. Max Faistenhammer. U. S. 2,022,541, Nov. 26, 1935 (April 19, 1930).

Rotating drawing-off basins attached to glass furnaces. Emile Roirant (Soc. anon. d'études et de constructions d'appareils mécaniques pour la verrerie). U. S. 2,023,746, Dec. 10, 1935 (Nov. 8, 1934).

Skimming devices for glass tanks or furnaces, and the gathering of charges therefrom. T. F. Pearson. Brit. 438,850, Dec. 4, 1935 (April 23, 1934).

Stirring molten glass in continuous tank furnaces. W. C. Taylor (Corning Glass Works). U. S. 2,022,223, Nov. 26, 1935 (May 13, 1932).

Take-out for glassware making machine. Edward Miller (Lynch Corp.). U. S. 2,022,939, Dec. 3, 1935 (June 17, 1933).

Transference of glass bottles, jars, etc., to leers. W. Forster. Brit. 437,265, Nov. 6, 1935 (Feb. 28, 1934).

Structural Clay Products

Effect of filler on the coefficient of friction on brick roads. K. W. Stinson and C. P. Roberts. *Proc. Nat. Paving Brick Assn.*, p. 41 (1935).—Through the use of a dynamometer truck it has been possible to study the variations in coefficient of friction between automobile tires and road surfaces. The tests have shown that the coefficient of friction of brick roads gradually decreases due to the exuding of filler which tends to cover the brick. The rolling and sliding stopping distances on a typical brick road were found to increase 50 and 57%, respectively, over a period of two years. M.C.S.

Face brick with 65 holes. W. W. Swengel. *Brick Clay Rec.*, **87** [5] 154 (1935).—Using a de-airing process and making the brick with 65 holes in it, the Royalton Face Brick Co., Middletown, Pa., has developed a lightweight face brick. Though one-third lighter in weight than regular face brick, these brick show an average compressive strength of 8037 lb./sq. in. in light-medium to hard-fired and 17,250 lb./sq. in. in hard-fired brick. Illustrated. E.J.V.

Highway bridges. J. R. Burkey. *Proc. Nat. Paving Brick Assn.*, p. 44 (1935).—Bridges built of brick add beauty to highway construction without increasing the cost. Reinforced brick masonry is the type of construction utilized. M.C.S.

Our way lies together. Bennett Chapple. *Brick Clay Rec.*, **87** [5] 163 (1935).—The future of brick in home building lies in the development of the steel house. Brick has the best chances with steel framing. Illustrated. E.J.V.

Science and new building materials. R. E. Stradling. Abstracted in *Brit. Clayworker*, **44** [523] 237–39 (1935).—Methods of judging building materials, plastering, brickwork, and masonry are discussed. The urgent need for building science is pointed out. R.A.H.

Standardization. Anon. *Clay Prod. News*, **8** [9] 3 (1935).—The Canadian Engineering Standards Assn. has set a new standard size for common and face brick. The average size of the brick shall be $8^3/_8$ in. long, $2^3/_8$ in. thick, and 4 in. wide. M.C.S.

Technic and practice in the production of brick and lime: XIX–XXII. Alberto Pellacini. *Corriere Ceram.*, **16** [7] 299–306 (1935).—Efflorescence on brick, the production of small paving block used in France, and face tile are dealt with. M.V.C.

BULLETIN

Effect of hydrochloric acid on brick walls. E. Suenson. *Ingeniorvidenskabelige Skrifter*, No. 40, 42 pp. (1935).—A series of tests dealing with the effect of hydrochloric acid on brick and masonry is described in detail. Illustrated. M.V.C.

PATENTS

Brick veneer and art of applying. S. Z. Trachtenberg. U. S. 2,024,312, Dec. 17, 1935 (Jan. 18, 1934).

Building block. H. J. Kaufman. U. S. 2,023,023, Dec. 3, 1935 (Dec. 29, 1934).

Building brick. V. A. Barnhart. U. S. 2,023,987. Dec. 10, 1935 (Oct. 10, 1933).

Building wall. L. S. Munson (Munlock Engineering Co.). U. S. 2,021,133, Nov. 19, 1935 (April 11, 1933).

Loading of sewer pipe, building tile, etc., for railway shipment. I. H. Spoor (Gerrard Co., Inc.). U. S. 2,024,189, Dec. 17, 1935 (March 31, 1931).

Perforated building brick or block. E. A. Stewart. U. S. 2,022,928, Dec. 3, 1935 (May 7, 1934).

Process for the manufacture of masses and articles having a porous cellular structure. Gustav Adolph and Theodor Pohl (Leichtbaustoff G.m.b.H.). U. S. 2,024,791, Dec. 17, 1935 (Jan. 20, 1933). A process for the production of masses and articles having a vesicular structure and in which materials capable of liberating oxygen are combined with binding materials consists in adding materials capable of effecting the liberation of oxygen by chemical conversion by which the added material undergoes chemical reaction in stoichiometrical proportions.

Waterproof wall construction. Bevan Jones. U. S. 2,024,524, Dec. 17, 1935 (Jan. 30, 1933).

Waterproofing of masonry walls. A. L. Larson. U. S. 2,023,425, Dec. 10, 1935 (Aug. 14, 1934).

Refractories

Acid and basic bottoms of copper refining furnaces. E. R. THEWS. *Metal Ind.* [London], **46**, 464–65, 513–14 (1935).—The success and economy of the copper refining process depends to a large extent on the character and quality of the hearth and its composite materials. The general quality and purity of the refined copper is considerably influenced by the hearth material. The suitability of the hearths of copper refining furnaces is based upon the following characteristic requirements: (1) high resistance against heat and corrosion, (2) impenetrability toward metals and the various products of the refining process (slags, etc.), (3) favorable mechanical properties, particularly high strength and elasticity under the normal conditions of the process, (4) ease of carrying out repairs quickly and simply, (5) ease of recovering the copper from the hearth material in case of repairs and renewals, (6) minimum wear by slagging, and (7) maximum absorptive capacity for the common impurities of copper. A number of basic and neutral materials are used for the hearths of copper refining furnaces, but silica, in one state or another, appears to give the best results. H.E.S.

Advanced and refined technique in the petrographic study of crystalline refractories. R. B. MCCORMICK. *Jour. Amer. Ceram. Soc.*, **19** [1] 7–13 (1936).

Application of highly refractory sillimanite materials in the glass industry. A. A. LITVAKOVSKIĬ. *Keram. i Steklo*, **11** [8] 26–28 (1935).—Details of experiments made with kyanite linings for pot and tank furnaces are given. The results showed that (1) kyanite linings resist the attack of the glass mass well, and (2) the character of the corrosion is different from that appearing in grog brick; while grog mixes obtain a "shell-like" appearance on their surface, kyanite linings become only uniformly thinner. M.V.C.

Application of physicochemical principles to the manufacture of refractory products. M. LÉPINGLE. *Ind. chim. Belge*, **6** [6] 217–22 (1935).—Phase-rule diagrams have led to a better understanding of "refractoriness"; their interpretation has made it possible to improve the quality of refractory products and also to explain causes of failure. The properties of aluminous refractories are considered. R.W.D.

Copper refinery furnace firing and refractories. H. C. ROBSON. *Metal Ind.* [London], **47**, 395–97 (1935).—In the production of blister copper, pulverized-coal firing gave the following advantages: (1) the firing cycle proceeds smoothly without interruption; (2) firing is under full control at all times; (3) during periods of inactivity firing can be instantaneously cut to the minimum; (4) choice of coal is wide and inferior grades may be used; and (5) fuel costs are reduced 55%. The only disadvantage is the collection of semifused coal ash in the flue and chimney. The best refractory results are obtained with larger sized silica brick and blocks. Fettling is best accomplished with a mixture of white quartz (ground to $^1/_8$-in. mesh) and 10% water. Detachable roof construction also gave good results. H.E.S.

Developments and trends in refractories: III. L. J. TROSTEL. *Brick Clay Rec.*, **87** [5] 164–68 (1935); *Blast Fur. Steel Plant*, **23** [11] 775–76 (1935).—The trend to substitute the improved basic brick for silica in points other than bottoms has grown as the insulation of furnaces has raised the temperature on the cooler side of the brick and increased the severity of fluxing and spalling conditions at the fire face of the brick. Refractories have been improved to meet specific conditions at other points in the manufacture of iron and steel, such as the high density deaired fireclay brick with increased heat capacity and a high-lime magnesite which sets quickly and is displacing pure magnesite for building up basic bottoms. The most advantageous applications of the new insulating refractories as furnace linings are for intermittently operated furnaces. Future developments are outlined. For Part II see *Ceram. Abs.*, **15** [1] 22 (1936). E.J.V.

Electro refractories. A. PAOLONI. *Corriere Ceram.*, **16** [7] 279–84 (1935).—The electrothermal treatment of raw materials for the production of refractory and ultrarefractory synthetic materials (silicon carbide products and artificial graphite) and a description of an electric furnace devised by P. for temperatures of 1400 to 1800°C are given. M.V.C.

Equipment used in crucible melting. R. H. STONE. *Trans. Amer. Foundrymen's Assn.*, **6** [1] 265–78 (1935).—Crucible melting recently has received an impetus due to the adoption of fuels not generally used previously, to better refractories, greater crucible life, and new furnace design. By basing the economy of fuel on the cost of a million heat units actually utilized, S. compares the costs of the various fuels available. He also outlines difficulties encountered with various fuels and ways of overcoming them and describes some new-type installations which are giving good results. In discussing refractories for crucible installations, he gives instructions on the care of furnaces that will improve melting conditions and lengthen crucible life. He also describes several special crucible furnaces that are being widely adopted and outlines the advantages of several typical installations. A chart analyzes the operating costs of modern crucible plants. H.E.S.

Evaluation of coke-oven refractories. ANON. *Refrac. Jour.*, **11** [10] 475 (1935).—Some of the important qualities of silica brick that fit them for coke-oven construction are discussed. The importance of porosity, permeability, and specific-gravity determinations of the marketed products is stressed in order that satisfactory performance can be assured. The practice of refiring underfired silica brick is discussed and considered permissible, if extra care is taken in this refiring. M.C.S.

Graphical method of calculating heat loss through furnace walls. C. E. WEINLAND. *Trans. Amer. Soc. Metals*, **23** [2] 431 (1935).—The usual method of calculating the heat loss from furnace walls consisting of layers of several types of materials is a tedious one. Either interface temperatures or thermal conductivities must be assumed and calculations must be made until the results obtained are consistent with conditions of the problem. A graphical method for the solution of problems in steady state of heat loss has been developed. Though this is still a trial and error method, it is more convenient and direct. The method is illustrated by the solution of a typical problem. J.M.K.

Hydraulic pressing of refractories. B. LASSMAN. *Ceram. Age*, **23** [6] 177 (1934).—The following phases of the hydraulic pressing of refractories are described: (*a*) changing the mold, (*b*) air elimination from the material by proper adjustment of multistage forming cycle, (*c*) high pressure forming, (*d*) ejection of brick, and (*e*) general operation directions. The following advantages are claimed for the method: (1) high forming or bonding pressures available, measurable, and under definite control, (2) sound ware at any forming pressure, (3) proper bonding of particles at maximum commercial pressures, for either maximum density or maximum spalling resistance, (4) uniform mass density and dimensions of ware, (5) production rates at a maximum to which the material lends itself, (6) high green strength, insuring protection of edges and corners with greater capacity to carry stacking loads, (7) repetition of each press cycle with regularity and precision, and (8) applied pressure adjustable in an infinite range as to intensity and rate of application. F.G.H.

Increasing use of magnesia and alumina refractory materials. R. *Feuerungstechnik*, **23** [10] 117 (1935).—The use of magnesia and alumina refractories in the steel, nonferrous, paper, and glass industries is briefly described. M.V.C.

Influence of iron compounds on chemical resistibility of grog refractories. P. P. BUDNIKOFF. *Ceram. Age*, **25** [4] 121–22 (1935).—Iron in various forms was added to mixes composed of clay grog and raw clay for the production of grog-block refractories. Iron additions contribute to the transformation of kaolinite to mullite. The transformation is effective only when the iron addition is made in a thinly dispersed and well-distributed condition. The mullitized material possesses marked resistibility to the influence of fused glass. Ocherous clay with high iron content in the form of iron hydroxide can be used as a rational and effective mullitizing addition. To obtain a deep mullitization the grog blocks should be fired at 1350 to 1380°C (2462 to 2516°F). Formations of mullite develop a crystalline concretion that protects the block from the influence of the glass; therefore the presence of a raised content of iron oxide does not influence visibly the coloring of colorless glass. The chemical resistibility of the block to the influence of glass is in considerable measure dependent on porosity and on its regular distribution in the mass of the block. The porosity of the block must be such as to secure its resistance to spalling. Illustrated. F.G.H.

Insulating fire brick in modern foundry practice. C. L. NORTON, JR. *Ind. Heating*, **2** [11] 654, 668–70 (1935).—Advantages and disadvantages of insulating fire brick when used in melting nonferrous metals and in the heat treatment of steel castings are outlined. Fuel savings are possible, and a few examples are described. Proper handling of the brick is an important factor for their behavior and life. M.H.

Insulation of open-hearth furnaces. GILBERT SOLER *Blast Fur. Steel Plant*, **23** [11] 799–800 (1935).—In open-hearth insulation, design and operation are affected; type of fuel and flame and draft control must be coördinated with new characteristics. Fuel savings due to insulation may amount to 15%. Insulating material must be selected and applied according to the properties of the material and the conditions under which it will be used. Insulation reduces conduction losses, air infiltration, and thermal spalling of refractories. E.J.V.

Kaolin and refractory clay in Sardinia. A. PELLOUX. *Ind. Vetro & Ceram.*, **8** [1] 18–30 (1935).—Italy is producing only 34,700 T. of kaolin and 66,000 T. of refractory clay while importing 250,000 T., worth 40,000,000 lire. Important deposits are worked in Sardinia (open pits). Although chemical composition is rather variable, alkali content is very low. Percentage of alumina (30%) and low plasticity allow this clay to be used as grog. It requires special treatment before being used for fine ceramics and, for this reason, can not compete with foreign raw materials. F.E.V.

Leucite, source of aluminium and potassium oxides. V. CHARRIN. *Ind. Chimique*, **22** [261] 739–40 (1935).—In mineralogy, the feldspar group also includes feldspathoids, *i.e.*, minerals having a similar chemical composition to that of feldspars; it may be mentioned that feldspathoids are to present eruptive rocks as feldspars are to ancient rocks. The most widely spread feldspathoid is leucite, $Al_2O_3 \cdot K_2O \cdot 4SiO_2$. This mineral, treated by alkaline or acid reagents, has long been employed for the production of aluminium and potassium oxides. Recently a new process of extraction has been suggested. A mixture of finely ground leucite and sodium chloride solution is treated in an autoclave by steam at 10 to 12 atmospheres pressure, and the following reaction takes place: $Al_2O_3 \cdot K_2O \cdot 4SiO_2 + 2NaCl = 2KCl + Al_2O_3 \cdot Na_2O \cdot 4SiO_2$ (analcime). Potassium chloride is separated by filtration. The residue mixed with limestone then undergoes calcination: $Al_2O_3 \cdot Na_2O \cdot 4SiO_2 + 8CaOCO_2 = Na_2O \cdot Al_2O_3 + 4(SiO_2 \cdot 2CaO) + 8CO_2$. Aqueous extraction gives $Na_2O \cdot Al_2O_3$ and dicalcium silicate is filtered off. The solution is next submitted to the action of carbon dioxide: $Na_2O \cdot Al_2O_3 + CO_2 = Al_2O_3 + Na_2OCO_2$. Alumina obtained by this method is in a state of great purity. It is possible to extract 90% of the potassium oxide and 80% of the alumina contained in the mineral. R.W.D.

Making burners and small furnaces from "Nernst" body. C. TINGWALDT. *Physik. Z.*, **36** [19] 627–29 (1935).—These burners and furnaces are being made from a mixture of approximately 85% zirconia and 15% yttria. Various methods of shaping articles are described. Laboratory furnaces made from this mixture may be heated up to more than 2000°C in air. W.M.C.

Manufacture of carbon brick. ANON. *Tonind.-Ztg.*, **59** [79] 978–80; [81] 1007–1008; [83] 1031–32 (1935).—A detailed discussion is given of the production of carbon brick, including raw materials, bonding agents, shaping, pressing, drying, and firing in various types of furnaces. M.V.C.

Manufacturing high-grade refractories. WALTER PETERS. *Allgem. Glas- & Keram. Ind.*, **26** [2] 2 (1935).—Mixtures of magnesium-aluminium-chromium oxides and silica, in definite proportions, are fused in an electric furnace and cast in molds. Raw materials should be pure. R.W.D.

Properties of clays from different sources. J. B. BLEWETT. *Trans. Amer. Foundrymen's Assn.*, **6** [2] 418–26 (1935).—B. discusses the properties of fire clays from

various districts. Necessary properties listed are bonding power, plasticity when mixed with water, retention of shape under heated conditions, and resistance to abrasion, fluxing, and spalling. Effects of grain shape and size on strength are discussed, and qualities of clays from various localities are compared. Effects of grinding and factors affecting plasticity and firing shrinkage are reviewed. One table compares the chemical composition of representative clays from various districts and another gives the firing properties. H.E.S.

Rammed mixes for cupola furnaces. Alfred Borsch. *Feuerungstechnik*, **23** [4] 41–43 (1935).—Rammed mixes are usually mixtures of high-grade refractory quartzites, with additions of clay or kaolin as bond, having an acid character. The mixing proportions depend on the requirements of the foundry and are adjusted accordingly. The resistance of ramming mixes depends first of all on their granulation and structure. However, these mixes possess the typical property of clay-quartz material, *viz.*, an expansion with increased temperature; therefore the temperature of the furnace should be raised slowly. This expansion is caused by the transformation of free silica which produces changes in the density of the structure. The critical temperature of highly siliceous materials lies between 100° and 900°C, so that when this span is passed too rapidly, the mixes may crack or spall, or their structure may become loose. M.V.C.

Refractories and their corrosion. P. P. Budnikoff. *Zhur. Prik. Khim.*, **7**, 439–54 (1934).—The chief destructive factors are chemical and thermal influences (about 80%), mechanical wear (15%), and other factors (5%). A classification of refractories is given, the limits of fusing temperatures of refractories are indicated, and the causes of thermal and chemical wear of all kinds of refractories (influence of slags, ash, oxides, gases, salts, etc.) are described. Ways of improving the quality of different refractories are suggested. The causes of wear of refractories are analyzed. P.B. & E.S.

Refractories for electric furnaces producing special irons. L. C. Hewitt. *Trans. Amer. Foundrymen's Assn.*, **6** [4] 577–88 (1935).—Certain developments in refractories and their applications to the direct- and indirect-arc furnaces are reviewed. The refractory problem is greater for the indirect-arc type and, with the possible exception of the direct-arc roof, different types of refractories are required. The introduction of a comparatively new type of refractory classified as super-fireclay brick has greatly aided in reducing refractory costs for the indirect-arc furnaces and should find application as a roof material for the direct. This refractory is noted particularly for its combination of low porosity and high thermal shock resistance together with high refractoriness and volume stability at high temperatures. Careful lining installation with minimum joints, use of proper bonding cement, precautions during preliminary heating, close control over superheating temperatures, and the use of special compounds, such as those of barium, as a metal cleanser and lining conditioner are among the service factors cited that bear upon the refractory performance. H.E.S.

Refractories for the electrothermic zinc industry. Winfield B. MacBride. *Bull. Amer. Ceram. Soc.*, **14** [12] 389–93 (1935).

Refractories and sands for the nonferrous industries. A. B. Searle. *Metal Ind.* [London], **46**, 75–76 (1935).—The nonferrous industries do not demand such highly refractory materials as the ferrous industries, but they usually require greater thermal conductivity and greater resistance to sudden temperature changes. The type of refractories used in the zinc, copper, brass, nickel, lead, and antimony industries is briefly pointed out. The properties of suitable foundry sands are given with references to the literature. H.E.S.

Refractories for smelting white metals. E. R. Thews. *Metal Ind.* [London], **47**, 154–56 (1935).—Although fireclay brick often give erratic results in lining furnaces for melting white metal, their service is more satisfactory than the more expensive basic brick. Most of the difficulties are due to leakage of the hearth and sides of the furnace. These difficulties are best overcome by proper selection of mortar, careful laying of the brick, and inclosing the lower part of the furnace in a steel casing. Further leakage may be prevented by melting broken glass (cullet) on the hearth forming a glossy surface that resists penetration. H.E.S.

Refractory lining for cupola furnaces. J. Robitschek. *Almanach mezinarodniho Sjezdu slevarenskeho* [Prague], pp. 385–98 (1934); abstracted in *Referat. Silikatliteratur.* No. 684 (1934).—Laboratory tests to determine the stability of grog brick against slag attack for cupola furnaces are discussed. M.V.C.

Refractory minerals and materials: Zirkite. Anon. *Refrac. Jour.*, **11** [10] 516 (1935).—Zirkite is one of the principal sources of zirconia. It occurs chiefly in Brazil in pebble beds on the surface of the ground and also as large veins underground. Zirkite alone is difficult to form into brick shapes, but with the addition of a small amount of clay it can be formed into refractory brick which will withstand temperatures as high as 2300°C. M.C.S.

Refractory problems in basic alloy steel production. Gilbert Soler. *Bull. Amer. Ceram. Soc.*, **14** [12] 383–88 (1935).

Semidry pressing of grog brick. Klesper. *Tonind.-Ztg.*, **59** [68] 812–14; [69] 834 (1935).—Experiments with the use of steam for moistening grog mixes are discussed. The steam treatment prevents the formation of lumps in the mix. M.V.C.

Solid reactions at 1000 to 1200°C between MgO or BeO and Ni, Fe, Cr, Mn, and their oxides. Louis Navias. *Jour. Amer. Ceram. Soc.*, **19** [1] 1–7 (1936).

Testing refractory mortar. Anon. *Tonind.-Ztg.*, **59** [63] 751–53 (1935) —A report of tests made at the chemical laboratory of the Tonindustrie on four kinds of refractory mortars and dealing with their properties and composition is given. M.V.C.

PATENTS

Apparatus for sintering refractory material. G. F. Taylor (General Electric Co.). U. S. 2,022,528, Nov. 26, 1935 (March 17, 1934).

Core for and method of producing hollow refractories. G. J. Easter (Carborundum Co.). U. S. 2,023,044, Dec. 3, 1935 (Dec. 18, 1933).

Crucible furnace. Furman South, Jr., and O. E. Neuhausen (Lava Crucible Co. of Pittsburgh). U. S. 2,024,707, Dec. 17, 1935 (Oct. 31, 1933).

Electrode furnace roof. H. A. McPherson (American Manganese Steel Co.). U. S. 2,021,424, Nov. 19, 1935 (Jan. 31, 1935).

End-wall construction for open-hearth furnaces. P. B. Tonnar. U. S. 2,021,245, Nov. 19, 1935 (Feb. 11, 1933).

Furnace construction. R. D. Foltz and R. C. Denny (M. H. Detrick Co.). U. S. 2,022,312, Nov. 26, 1935 (Nov. 18, 1931). Konrad Hofmann. U. S. 2,023,174, Dec. 3, 1935 (Feb. 16, 1934).

Furnace structure. L. T. Petit. U. S. 2,024,595, Dec. 17, 1935 (Jan. 31, 1935). In a furnace structure, a body of brickwork in which some of the brick have faces inclined with relation to their opposite faces and the inner faces of some of the brick being offset from others so as to provide inner undercut pockets, and an inner lining, of material characterized by its resistance to attack by basic substances when highly heated, interlocked with the pockets.

Furnace walls, furnace gas, baffle-plates, etc. Witkowitzer Bergbau- und Eisenhütten Gewerkschaft and B. Belohlavek. Brit. 439,143, Dec. 11, 1935 (Dec. 7, 1934).

High-temperature furnace insulated wall construction. A. S. Nichols (Illinois Clay Products Co.). U. S. 2,021,742, Nov. 19, 1935 (June 18, 1934).

Method and apparatus for producing fused refractory and abrasive materials. R. C. Benner and G. J. Easter (Carborundum Co.). U. S. 2,021,221, Nov. 19, 1935 (Jan. 20, 1933).

Method of producing pure alumina. Wilhelm Fulda, Erich Wiedbrauck, and R. R. B. Wittig (Vereinigte Aluminium-Werke A.-G. and T. Goldschmidt A.-G.). U. S. 2,021,546, Nov. 19, 1935 (June 1, 1934).

Refractory anchor. George Quint. U. S. 2,021,610, Nov. 19, 1935 (June 14, 1934).

Refractory material. G. D. Cain (Republic Steel Corp.). U. S. 2,021,222, Nov. 19, 1935 (Nov. 17, 1933). A refractory consists of between about 5 and 15 parts by weight of olivine containing about 48% MgO, 42% SiO_2, and 2 to 20% FeO, about 5 and 15 parts by weight of chromite containing $FeOCr_2O_3$, and about 5 and 15 parts by weight of calcined dolomite containing CaO and MgO.

Terra Cotta

Acid-resisting stoneware. K. Dehne. *Chem. Age*, **33**, 141 (Aug. 17, 1935).—Acid-resisting stoneware is now being produced in exceptionally good quality, especially when made under vacuum. H.H.S.

Ceramic roofing granules. E. H. Berger. *Ceram. Age*, **25** [2] 49–51 (1935).—The development of manufacturing processes for the production of ceramic roofing granules is described in detail. The essential properties of an ideal ceramic roofing granule are as follows: (1) it should be of relatively low cost; (2) the color should be permanent and uniform; (3) the granule should be opaque rather than transparent or translucent and of low reflectivity; (4) it should be nonstaining, relatively nonabsorbent, and nonblistering; (5) it should wet well and embed readily in hot asphalt coating; (6) its adhesion to asphalt coating should be good under all weather conditions; (7) it should resist freezing, thawing, and rapid changes of temperature without disintegration of the body granules or spalling of the glaze; (8) it should be free from soluble salts which under the proper conditions of moisture and temperature might cause efflorescence or shedding of the granules from the roofing; (9) it should withstand the abrasion incidental to handling and shipping; and (10) it should be of such shape and grading that a minimum segregation of sizes will occur in handling, shipping, and storage and that the edges of the granules will overlap so as to cover the asphalt coating completely. F.G.H.

Defects in manufacturing oven tile. W. P. *Allgem. Glas- & Keram. Ind.*, **25** [1] 25–26 (1934).—The following defects are examined: (1) excessive shrinkage in drying and firing, (2) scaling, running down, blistering of glaze, (3) lack of luster, and (4) faintly, cloudy, patchy, and crizzled glazes. R.W.D.

Engobes for roof tile. Anon. *Tonind.-Ztg.*, **59** [84] 1039–41 (1935).—The production of gray engobes for roof tile is described. M.V.C.

Is too much cement dangerous? J. R. Kaufmann. *Keram. Tile Jour.*, **7** [10] 14 (1935).—Failures of tile installations such as the fracturing of the tile and the crazing of the glaze are due, in many instances, to improper mortar compositions used for setting the tile. M.C.S.

Pinholes in glazed ware, their cause and remedy. Maurice Barrett. *Brit. Clayworker*, **44** [523] 226–28 (1935).—B. discusses the reasons for the occurrence of pinholes under the following classifications: (*a*) those produced by chemical action during firing, which are directly attributable to the evolution of gas at a comparatively late stage of firing, and (*b*) those produced mechanically by air prior to firing; this constitutes the major cause of pinholes. In the first class the trouble may be caused by the presence in the glaze of (1) a sulfate radical, (2) high zinc content, especially if associated with high alumina, (3) particles of plaster molds, (4) organic matter which oxidizes or decomposes, (5) Cornwall stone which contains fluorine, (6) grains of pyrite, and (7) soluble constituent which may concentrate on the surface of the glaze. Other causes may be the use of a body which is neither vitreous nor highly porous or the excessive concentration of steam or carbon dioxide in the kiln atmosphere. Under the cause of mechanically produced pinholes, B. discusses (1) the fact that thorough weathering may increase or reduce them, (2) too long aging of prepared mixture, (3) insufficient tempering, (4) saturation with water of thin articles during dipping or spraying, (5) fermentation in engobes, (6) dry dust falling into the glaze, (7) use of freshly made slips, (8) introduction of too much air during blunging because of high viscosity of slip or rapid agitation, (9) addition of certain quality of gums to slips, (10) too great an interval of time between application of different coats of glaze, (11) flat dipping, (12) use of wet or badly worn plaster molds, (13) fettling articles when they are too hard, and (14) presence of dust on the surface of the clay or biscuit articles. R.A.H.

Raw leadless glazes for pottery and tile at cone 2. C. W. MERRITT. *Jour. Amer. Ceram. Soc.*, **19** [1] 23–25 (1936).

Tile in the model home of America. A. K. CHESTER. *Keram. Tile Jour.*, **7** [8] 7 (1935).—C. describes how floor and wall tile were used in the Model Home of America at Atlantic City, built under the auspices of the FHA. Many types of tile were used in the bathrooms, game room, porches, laundry, and stairways. Illustrated. M.C.S.

PATENTS

Method for the manufacture of flowerpots. L. WATKINS. Brit. 439,116, Dec. 11, 1935 (May 29, 1934).

Roofing tile and brick formed of porous material. W. ELBORNE. Brit. 437,851, Nov. 20, 1935 (Nov. 26, 1934).

Whiteware

Cracks upon the glazed surfaces of ceramic ware (preliminary report). HIROSI HUKUSIMA. *Sci. Papers, Inst. Phys. Chem. Research*, **27**, 235–43 (1935).—A statistical study of the cracks in the glaze of circular bowls and dishes is presented. Different kinds of cracks are distinguished: the primary cracks formed shortly after glazing, which in this case are blackened, and uncolored cracks formed later. The latter tend to form at right angles to the former. No very definite results were obtained. J.B.A.

Edwin Bennett Pottery. ANON. *Ceram. Age*, **25** [3] 89 (1935).—The development of the plant and the products of the oldest operating pottery in the U.S. are described and illustrated. F.G.H.

Effect of a tremolitic talc in whiteware bodies. DONALD HAGAR. *Jour. Amer. Ceram. Soc.*, **19** [1] 14–23 (1936).

Imitation porcelain faience of the Porelite and Grindley-Ware type. Nature and composition of these products. M. LARCHEVÊQUE. *Céramique*, **38** [569] 179–92 (1935).—L. compares imitation porcelain to true porcelains from the standpoint of absolute and apparent density, porosity, and resistance to shock. M.H.B.

Manufacture of electrical porcelain specialties. J. B. NEALEY. *Ceram. Age*, **25** [5] 150–51 (1935).—The formation of electrical porcelain specialties at the Central Porcelain Co. is briefly described. The gas-firing of the products in periodic downdraft kilns is discussed in more detail. Illustrated. F.G.H.

Porcelain in surge-proof distribution transformers. W. A. SUMNER. *Ceram. Age*, **24** [5] 133–35 (1934).—The application of many types of porcelain insulation in surge-proof distribution transformers is illustrated and described. F.G.H.

Whiteware at cone 06 biscuit, cone 015 glost. A. E. BAGGS. *Ceram. Age*, **24** [6] 163 (1934).—Bodies which have reasonable strength and density when fired at cone 06 are very high in flint and contain an auxiliary flux. The clay content is low, and plasticity is fortified by the use of bentonite. Glazes used are of the general type of leadless cover-coat enamels for metal. F.G.H.

PATENTS

Arc-extinguishing device. A. M. JACKSON (Locke Insulator Corp.). U. S. 2,022,962, Dec. 3, 1935 (Dec. 30, 1926; Jan. 29, 1930).

Article of tableware. R. G. COWAN (Onondaga Pottery Co.). U. S. 2,024,995, Dec. 17, 1935 (Aug. 6, 1934). An article of china or porcelain tableware comprises a dish having a relatively flat bottom surface surrounded by a rim portion, in combination with ornamentation of the rim consisting of depressed portions, which depressed portions terminate toward the center of the plate at a shoulder or edge and extend outwardly from the terminus in a slope merging with the surface of the rim.

Ceramic flux and process of making. J. H. WEIS (Feldspathic Research Corp.). U. S. 2,024,407, Dec. 17, 1935 (Jan. 6, 1934). A process of producing a ceramic flux for whiteware, wall tile, etc., comprises combining with partially kaolinized pegmatite, feldspar, lime, and flint in such proportions as to produce a flux having the characteristics of English Cornwall stone and having a silica content of 70 to 74, alumina of 15 to 17, potash of 2.5 to 4.5, soda of 2.5 to 4.5, and lime of 1 to 3%, and having an Fe_2O_3 content of less than 0.1%.

Insulator. E. M. MEYER (Porcelain Products, Inc.). U. S. 2,024,831, Dec. 17, 1935 (June 2, 1933).

Shielded cemented-type insulator. K. A. HAWLEY (Locke Insulator Corp). U. S. 2,023,808, Dec. 10, 1935 (Feb. 16, 1933).

Equipment and Apparatus

Advantages of ball (rod) mills of larger diameters and advantages of improved bearings. WILL H. COGHILL, FRED D. DEVANEY, AND R. G. O'MEARA. *Trans. Amer. Inst. Mining Met. Engrs.*, **112**, 79–87 (1934).—Because of the common belief that big mills economize in floor space and first cost, the trend has been to larger units. But the advantage with respect to friction has not been clearly defined. Larger commercial mills are shown to be both lighter and lower in friction (weight times r.p.m.) per unit of net power—grinding capacity. Some recovery may be made of the relatively high losses in small mills by installation of frictionless bearings. A.P.

Coating spray-booth interiors. ANON. *Ind. Finishing*, **11** [10] 12 (1935).—"Kelsanite" is a liquid rubber which can be sprayed on the interior of a spray booth. It hardens quickly to form a protective coating for the booth. Whenever the booth is to be cleaned the Kelsanite coating can be peeled off by hand or blown off by inserting an air hose under the surface and pulling it free by inflating the space between wall and coating. Thus a cleaning job ordinarily requiring several hours can be completed quickly. Illustrated by photos taken at the plant of the Detroit Steel Products Corp. J.L.G.

Crushing and grinding. W. F. CAREY. *Trans. Inst. Chem. Engrs.*, **12**, 179–85 (1934).—The low energy efficiency (only 1%) of existing machines is due mainly to

losses in the transmission of energy from the shaft to the particles being crushed. Over-grinding accounts for relatively small energy losses, but large frictional losses are introduced through crushing beds of powder. In practice it is impossible to provide the enormous grinding surface theoretically required. Ball mills and ring roll machines, *e.g.*, Raymond, Sturtevant, and Lopulco, always tend to form aggregates. Impact mills, such as the Atritor, Clark Chapman Resolutor, and Miracle Mill, suffer excessive windage losses due to air friction. The high speed roll crusher offers most scope for the development of a more efficient appliance. See also *Ceram. Abs.*, **14** [2] 44 (1935). G.H.A.

De-airing ceramic mixes. ANON. *Corriere Ceram.*, **16** [7] 307–11 (1935).—The principle of the de-airing process and German and American patents on the process are explained. The improvement of ceramic mixes by de-airing is shown, but the type of installation chosen should be that best suited to the material to be treated. M.V.C.

De-airing of clay: Australian machine. O. R. RICHTER. *Clay Prod. Jour. Australia*, **2** [12] 11–13 (1935).—The first de-airing machine to be made in Australia is by J. Welsh, Melbourne. It is a motor-driven auger machine and mixer with SKF bearings, grease-lubricated. H.H.S.

Density determination of a small grain. W. F. DE JONG. *Zentr. Mineral. Geol. A*, pp. 140–42 (1935).—Densities of single grains of approximately 1 mg. weight may be determined by measuring the rate of fall in a water-filled glass vessel of a calibrated small glass float loaded with the grain. Methods of calibration are given. H.I.

Determining uneveness of floor tile. NITZSCHE. *Tonind.-Ztg.*, **59** [73] 904 (1935).—An apparatus used for measuring uneven surfaces of floor tile is described. M.V.C.

Determining uneveness of the surface of floor and wall tile. R. BARTA. *Tonind.-Ztg.*, **59** [66] 791–92 (1935).—The apparatus used to measure surface uneveness of tile is described. M.V.C.

Fine-grinding fundamentals. A. W. FAHRENWALD. *Trans. Amer. Inst. Mining Met. Engrs.*, **112**, 88–115 (1934).—Factors involved in ball-mill performance, *viz.*, speed of rotation; diameter and length of mill; load, density, and shape of balls; and size, load, and water ratio of the feed, are discussed. A.P.

Heat of vaporization of water, and the specific volume of saturated water-vapor, up to 202 kg./cm.² (365°C). M. JAKOB AND W. FRITZ. *Physik. Z.*, **36** [20] 651–59 (1935).—The calorimetric determinations have been extended up to 202 kg./cm.² (365°C). An empirical formula has been derived including the entire range from 0 to 372°C. W.M.C.

Liquid and plastic rubber for coating. SELF-VULCANIZING RUBBER CO. *Ind. Finishing*, **11** [10] 45–46 (1935).—Liquid and plastic rubber for use as protective coatings against corrosion, abrasion, chemicals, and damage or noise from impact are said not to deteriorate with age and to withstand temperatures from −120°F to +200°F. A coating one mil thick will not rupture (physically or electrically) at 440 volts. Coatings can be dipped, brushed, sprayed (liquid rubber), or applied with a trowel (plastic rubber). J.L.G.

Measuring waste-gas temperature. E. GRAF. *Feuerungstechnik*, **23** [9] 100–102 (1935).—An "extrapolation" thermometer and its operation and use in practice are discussed. M.V.C.

Moisture-expansion tests. C. C. TREISCHEL. *Ceram. Age*, **25** [2] 46–48 (1935).—A simple, inexpensive, and accurate apparatus for measuring the moisture expansion of tile and other products is described. The results of autoclave tests on commercial wall tile are presented graphically. Typical cumulative moisture-expansion curves are given for commercial wall tile of both the high and low moisture-expansion type. Several types of curves are shown, including cumulative and continuous at constant pressure and variable pressures for one hour. The effect of the cumulative test on the crazing of glazed tile was more severe than the continuous test. Moisture-expansion determinations were made on china clays and kaolin fired to cones 8 and 12, the results of which are presented graphically. Secondary kaolins are more resistant to moisture expansion than primary kaolins and china clays. The most logical procedure in developing a craze-proof product is first to develop a body that meets desired specifications of cost, workability, and low moisture expansion, and then to fit a glaze to it. F.G.H.

More jobs for electron tubes. L. R. HARNESS. *Factory Management & Maintenance*, **93** [11] 476–77 (1935).—A photoelectric system has been installed on scales to catch short cases of coffee passing over the scales in continuous conveyer operation. No shortage has escaped notice by this detector. Electron tubes regulate the tension of rubber tread stock being transferred from one conveyer to another. They control punching operations on automatic punch presses. They protect pedestrians at a crossing in a Pittsburgh steel mill by sounding an alarm whenever a train or truck approaches the crossing and intercepts the light beam. Rectifier tubes are used in the manufacture of sandpaper to furnish rectified high voltage which, through suitably placed electrodes, holds the abrasive grains with their long axis perpendicular to the paper during the gluing operation, thus providing an abrasive paper of 30 to 40% increased life and efficiency. Supply and storage tanks may automatically be kept filled to any desired level through photoelectric control. In a high-voltage testing laboratory, entering engineers are protected by a photoelectric eye. A bakery has installed a photo tube to call attendants when bread starts through on the conveyers. A photo tube prevents an overload from occurring on a conveyer serving the cold room of an ice-cream plant. J.L.G.

Motion of granular or pulverous materials in a horizontal rotating cylinder: II, Mechanism of mixing and the determination of mixing velocity. YOSITOSI OYAMA. *Bull. Inst. Phys. Chem. Research*, **14**, 570–83 (1935); English abstract in *Sci. Papers, Inst. Phys. Chem. Research*, p. 40, July, 1935.—The mechanism of mixing of granular materials in a rotating cylinder has been studied experimentally. Motion pictures of a cross-section of the cylinder show that the degree of mixing is a function of time and of speed of rotation. A relation between these quantities has been derived. **III, Effect of cylinder diame-**

ter on the state of motion of materials. *Bull. Inst. Phys. Chem. Research*, **14**, 770–80 (1935); English abstract in *Sci. Papers, Inst. Phys. Chem. Research*, p. 52, Sept., 1935. The speed of rotation which gives the same state of motion is given by $N = C/D^{0.47}X^{0.14}$ where N = r.p.m. of cylinder, D = diameter of cylinder in meters, X = volume occupied by material in per cent, and C is a constant. J.B.A.

Photoelectric cells in modern measuring technique. A. KARSTEN. *Messtechnik*, 9 [1] 6-8 (1935).—The use of photoelectric colorimeters, Lange photoelectric apparatus for measuring reflection and illumination, polarization apparatus, etc., is described. M.V.C.

Photographs of minerals with the electron microscope. H. MAHL. *Mineral. Petrog. Mitt.*, **46**, 289–92 (1935).—The arrangement of the electron microscope is described and illustrated, and comparison photographs of galena and chalcopyrite with the electron microscope and metallographic microscope are given. H.I.

Photomicrography outfit. H. WRIGHTON. *Jour. Roy. Microscop. Soc.*, **55** [2] 79–82 (1935).—The newly designed instrument has a provision for critical vertical illumination for specimens when photographed at low magnifications using short-focus lenses. Other special features are described. Illustrated. G.R.S.

"Photomicroscope," a means for rational analysis of clinker. EBERHARD SPOHN. *Tonind.-Ztg.*, **59** [70] 849–52 (1935).—A new "photomicroscope" similar to that used in metallography is described, and its application for studying cement is dealt with. The method has the following advantages: (1) a clear picture with sharply defined contours of the crystals, (2) simple preparation of the sample, and (3) easy determination of the mineralogical structure and homogeneity of the material. The study of various cements showed crystals of $3CaO{\cdot}SiO_2$ imbedded in the ground mass without any structure, which can be regarded as glass. M.V.C.

Profile microscope, an auxiliary for examining fine polished surfaces. W. HASSELBECK. *Schleif & Poliertech.*, **12** [2] 34 (1935).—If a horizontal surface with irregular texture is lighted vertically, it is easy to limit the rays sharply by a screen. The limit of shade is a well-defined line which, observed nearly tangentially, may serve as a profile line, *i.e.*, a cross-section of surface by a vertical plane. This principle has been transposed to a microscope with the restriction that, instead of observing tangentially, the incidence of ray is practically 60°. Magnification is about 100×. Photomicrographs are taken, allowing the state of surface to be characterized by numbers. Illustrated. F.E.V.

Research in drying clayware. J. L. CARRUTHERS. *Ceram. Age*, **25** [2] 53 (1935).—The mechanism of the various phases of clay drying is described, and lines of investigation and research of drying problems are indicated. F.G.H.

Summary of investigation on work in crushing. JOHN GROSS. *Trans. Amer. Inst. Mining Met. Engrs.*, **112**, 116–29 (1934).—Within the last few years the study of the energy used in crushing has advanced from a period of perplexing confusion to one of greater clarity. The Rittinger theory that the energy required in successive steps in reduction increases geometrically has now been established. The meaning and nature of subsieve material has also been clarified. There are still needed a simple, direct method for determining surface on a crushed product, a simple and accepted elutriation or sedimentation method for size determination on a −400-mesh material, and investigation of new means to accomplish comminution. The bibliography includes 128 references to work on crushing. A.P.

Thermocouples. W. PRATT. *Trans. North East Coast Inst. Engrs. and Shipbuilders*, **51**, 103–18 (1934–35).—A mathematical discussion of thermoelectric effects, power, and energy-temperature curves for base and noble metal couples is presented. An appendix gives calibration tables for various batches of thermocouple wire. The methods for hooking up temperature-measuring systems are discussed and given diagramatically in respect to economy in use of short thermocouple leads and a minimum of cold junctions. W.H.B.

Welded press die boxes. R. H. ASCOUGH. *Brit. Clayworker*, **44** [523] 237 (1935).—Press die boxes made by electric welding of corners and sufficiently oversize to permit the use of replaceable liners are described. R.A.H.

BOOK

Areometer method for determining grain distribution in soils and other materials. A. CASAGRANDE. Ludwig Springer, Berlin, 1934. 56 pp. Price 4.50 Rm. Reviewed in *Tonind.-Ztg.*, **59** [77] 960 (1935). M.V.C.

PATENTS

Apparatus for the automatic grinding of crystals. M. E. STRIEBY (Bell Telephone Laboratories, Inc.). U. S. 2,023,494, Dec. 10, 1935 (Dec. 5, 1934).

Apparatus for manufacturing articles of porcelain, etc. V. G. MANUFACTURING CO., LTD., AND F. M. VAN GELDEREN. BRIT. 438,507, Dec. 4, 1935 (March 9, 1934).

Apparatus for use in glazing brick, tile, etc. F. G. GATENSBURY AND J. H. BOYCOTT. Brit. 437,968, Nov. 20, 1935 (May 12, 1934).

Clayworking. D. E. CHILD AND J. L. CHILD (Hancock Brick & Tile Co.). U. S. 2,024,025, Dec. 10, 1935 (April 25, 1934).

Furnace. WILLARD ROTH AND F. X. KERIN (Westinghouse Electric & Mfg. Co.). U. S. 2,023,101, Dec. 3, 1935 (July 10, 1934). A furnace structure includes refractory walls enclosing a furnace chamber on all but one face thereof, a double-wall structure substantially coextensive with the refractory walls and surrounding the same, a cover for the open face of the chamber, and means for causing circulation of gas through the chamber, between the cover and the adjacent face of a wall, and through the double wall structure.

Hydraulic press. H. J. MCKAY AND P. J. CARLSEN (Richardson Co.). U. S. 19,780, Dec. 3, 1935; reissue of original 1,919,070, July 18, 1933.

Metering apparatus for mixing machines. SAMUEL SHAFER, JR., AND C. F. BALL (Chain Belt Co.). U. S. 2,025,003, Dec. 17, 1935 (Aug. 18, 1931).

Method and apparatus for decorating surfaces. L. V. CASTO. U. S. 2,023,463, Dec. 10, 1935 (June 14, 1934).

Method for effecting by pressure the face grinding of hard material surfaces. G. F. BRENDEL (Soc. anon. dite: Soc. Marbriere de Paris). U. S. 2,023,572, Dec. 10, 1935 (Dec. 14, 1933).

Method for treatment of ceramic materials. MARSHALL LASLEY. U. S. 2,023,426, Dec. 10, 1935 (Feb. 8, 1933). A method of treating clay or shales containing volatilizable impurities and a high proportion of hydrated, plastic clay substance comprises reducing them to finely divided condition and subjecting to heat in intimate contact with an oxidizing atmosphere at a temperature sufficient to oxidize and volatilize the impurities and thereafter at a temperature sufficient partially to dehydrate the clay substance.

Mold-shaking machine for foundries, ceramic works, etc. G. ZIMMERMANN. Brit. 438,394, Nov. 27, 1935 (Dec. 7, 1933).

Ramming-machines for molding brick, slabs, blocks, etc. C. NINGELGEN AND R. W. GEDDES. Brit. 438,755, Dec. 4, 1935 (Nov. 26, 1934).

Roll- and bar-grinding mill. ASBJORN SONSTHAGEN. U. S. 2,024,073, Dec. 10, 1935 (Aug. 20, 1934).

Kilns, Furnaces, Fuels, and Combustion

Ceramic ware firing. ROSS C. PURDY. *Bull. Amer. Ceram. Soc.*, **14** [12] 398–99 (1935).

Coal in the ceramic industry. H. E. NOLD. *Ceram. Age*, **25** [1] 19 (1935).—N. discusses the characteristics of the ideal coal for the ceramic industry and lists the properties of six bituminous coals which have been found satisfactory for kiln firing. Periodic and continuous kilns are discussed with respect to the type of fuel used. The following observations are made: (1) High-volatile coals are the most desirable of the solid fuels for kiln firing, although low-volatile coals can be used. (2) Producer gas is a desirable fuel and profitable in some of the larger plants. (3) Natural gas, the greatest competitor of coal for kiln firing, has largely replaced coal for firing finer ware, but it can not compete with coal in firing heavy clay products except in regions where cheap gas is available. (4) Coal producers could increase sales by furnishing expert firing instruction. F.G.H.

Electric tunnel kilns. H. WILLACH. Report at the "Märkis" District Group, Deutsche Keramische Gesellschaft, Jan. 24, 1934; abstracted in *Referat. Silikatliteratur*, No. 111 (1934).—All electric tunnel kilns are heated with electrical heating elements (resistors) which are of different materials and shapes according to the temperature to be obtained. Low-temperature tunnel kilns are operated at temperatures up to 900°; medium temperature kilns, at temperatures of 900 to 1100°; and high temperature kilns, at temperatures over 1100 to 1400°. For low temperature kilns chrome-nickel alloys are used for the heating elements. Metal alloys are also used for the heating elements in medium temperature kilns; two typical makes are the Megapyr of Heräus, a chrome-nickel material with a relatively high iron content, and the Swedish Cantal. This heating element can be used up to temperatures of 1300°, but at higher temperatures the material loses tenacity and becomes very plastic. In America, carbon elements are still used and most pipes are of silicon carbide, which are filled with carbon. Here also belong the Morganit plates of the Morgan Crucible Co., London. These are made of carbon with a protective covering. For high temperature kilns silicon carbide rods are used as the heating element. Silit and Globar are well known; they differ essentially only in form. Globar rods are made in cylindrical shape; the contact is made through water-cooled metal feeders. Silit rods have thickened ends, to which the feeding wire is connected. There are no difficulties of contact with Silit rods.

Low-temperature kilns are used almost exclusively for firing decorations on porcelain and whiteware. For the kiln of Brown, Boveri & Co., the firm specifies a specific consumption of current of 0.75 kw.-hr./kg. ware. For electrical counter-current kilns with heat recovery (Siemens-Schuckert Works) for firing colors on porcelain, the consumption of current is smaller and is specified as 0.4 kw.-hr./kg. ware. The ratio of ware to crates (1:1.5) is better than the 1:2 of the kilns of Brown, Boveri & Co. The glaze firing of cups in medium temperature kilns is referred to; the kiln is constructed as a one-track furnace, but it has an exchange chamber for better efficiency so that the fired ware can give off heat to the new charge. The kiln, which is only 10 cm. high, is heated from above with Morganit plates; the output of the kiln is 600 cups per hr. The life period of Morganit plates is long, but the contacts break off easily and there is poor connection between plates and current supply. The specific current consumption for 100 cups is only 0.133 kw.-hr. In America, low-temperature kilns are used chiefly and in some cases medium-temperature kilns; high-temperature kilns are not generally found. A high-temperature kiln is referred to which is heated with Globar rods and is used for firing sanitary whiteware. As in the case of all silicon carbide rods, the resistance increases with time. Therefore degree transformers are used for equalization. The kiln is provided with supplementary heating at the preheating end. The output of the kiln is 210 normal wash stands in 24 hr. It is interesting that it is possible to fire fireclay in 48 hr. in this kiln, a very short time. The specific consumption of current is 1.24 kw.-hr./kg. ware, determined on fire clay. In the sanitary-ware industry the conditions for the use of electrically heated tunnel kilns are especially good, as the pieces can be placed directly on the wagons and no ballast has to be heated. In other ceramic industries crates or saggers, etc., are essential so that the economy of electric heating seems doubtful. Where the proportion of ware to saggers is 1:2, an economy is obtained in firing porcelain with electricity. The question of the stability of the heating rods and their cost is undeniable. On an average, the rods will stand 2000 hr. of firing; consequently the rods must be changed four times a year. Repair costs other than replacing the rods are not to be expected with an electric kiln because temperature regulators prevent overheating. Exchanging the rods is simple and comparatively quick. Countries with a poor fuel supply, *viz.*, Switzerland and Italy, show a great interest in electrically heated furnaces. There is an economy in the cost of current of 4 pfg./kw.-hr. (according to findings in an experimental kiln). In Germany the economy was 2 pfg./kw.-hr. In Switzerland a furnace in operation had, at most, 1% waste

in the manufacture of fire clay. Electrically heated tunnel kilns are not yet in use in Germany; all knowledge of them is based on experience in other countries. M.V.C.

Firing a brick kiln more efficiently. J. G. SEANOR. *Brick Clay Rec.*, **87** [5] 156–57 (1935).—The functions of a kiln which should be as perfectly coördinated as possible are (1) to generate hot furnace gases, (2) to apply these furnace gases to the ware, and (3) to remove the resulting kiln gases. The function of a fire box is to generate furnace gases in sufficient quantities and at the proper temperature to process the ware. Methods of changing from oxidizing to reducing conditions and *vice versa* are discussed. There must be enough space leading from the furnace into the kiln so that the heated furnace gases can get over into the ware readily where they are needed. The correct level for the fuel bed is discussed. Illustrated. E.J.V.

Flowerpot manufacture with natural gas fuel. C. W. GALE. *Ceram. Age*, **24** [3] 73–74 (1934).—The advantages of natural gas over sulfur-bearing coal are outlined. Soluble sulfates, formed in the ware through the use of sulfur-bearing coal, are absorbed by the soil used in flowerpots and retard plant growth. Natural gas, in regions where it is readily available, provides a greater uniformity of pot texture and a reduced over-all cost through the virtual elimination of rejects and the minimizing of labor for firing. F.G.H.

Heating intermittent furnaces. V. BODIN. *Céramique*, **38** [568] 156–64 (1935).—The use of gas, heavy fuel oil, and automatic coal stokers in the ceramic industry is discussed. M.H.B.

Investigations of whiteware firing kilns. ANON. *Keram. Rundschau*, **43** [4] 37–39; [5] 49–54; [6] 64–66; [7] 75–77 (1935).—Kilns with ascending and with horizontal flames were investigated. Full data concerning dimensions, fuel consumption, heating schedules, local differences of temperature, and efficiencies are tabulated. The origin of defects is determined. Modifications and waste-heat recuperation are suggested. F.E.V.

Liquid and gaseous fuels. F. M. *Rev. gén. Sci.*, **45** [2] 38–39 (1934).—Liquid and gaseous fuels are convenient; they are stored in tanks or reservoirs. The firing operation is simplified with such fuels because they permit an easy regulation of the combustion. A description of these fuels is given. M. also mentions colloidal fuels which result from a mixture of fuel oil (60%) and finely powdered coal (40%) kept homogeneous by means of combined chemical and mechanical processes. R.W.D.

Oil- and gas-fired furnaces. RUDOLPH BOYE. *Eng. Prog.*, **16** [8] 199–204 (1935).—Types of oil and gas furnaces used in the heat treatment of steel and nonferrous metals in German practice are described and illustrated. J.L.G.

Paper dampers which fail. ANON. *Brit. Clayworker*, **44** [523] 230 (1935).—The paper for dampers should be thin, tough, brown, free from pinholes and wide enough so that not more than two sheets are needed for one damper. It should be sufficiently waterproof not to break down under the softening effect of any condensed water-vapor which may settle on it. When a paper damper fails and the fault is not with the quality of paper, the cause usually is due to insufficient drying by heated air prior to admitting kiln gases. R.A.H.

Recent developments in electric furnaces for nonferrous metals. A. G. ROBIETTE. *Metal Ind.* [London], **46**, 355–57, 383–85 (1935).—The various types of heat-treatment and annealing furnaces are illustrated and described with special attention given to controlled atmospheres in annealing. H.E.S.

Smoke analysis by electric oxygen meter. R. W. LEONHARDT. *Zement*, **24** [12] 172 (1935).—Determination of O_2 in waste gas gives more reliable information than that of CO_2. Thermal conductivity of O_2 being only 1% greater than that of air, a makeshift is used in the new apparatus of Siemens and Halske. An excess of H_2 is introduced in waste gas, the conductivity is measured, H_2 is burned in proportion to O present, and the new conductivity is measured. The difference gives an accurate determination of O_2, the error not exceeding 0.3%. The apparatus is fully described. Illustrated. F.E.V.

Solid fuels. F. M. *Rev. gén. Sci.*, **44** [22] 630–32 (1933).—Although coal has been known for a long time, its extensive use dates back about only one century. In 1815, the French coal consumption did not exceed 1,000,000 T. It rose to 8,000,000 T. in 1860 and, at present, it amounts to about 75,000,000 T. yearly. A classification of solid fuels and considerations of their technical properties are given. R.W.D.

Tunnel kiln operating problems. DWIGHT B. HENDRYX. *Brick Clay Rec.*, **87** [5] 160 (1935).—Practical suggestions on getting better service and higher quality ware, based on the experience of many years of firing tunnel kilns, are offered. E.J.V.

BOOK

Kilns and Furnaces of the Glass and Porcelain Industry. G. A. UDOVENKO. State Pub. Light Ind., Moscow, 1935. 234 pp. Price 3R 60k. This book is an elementary textbook for students connected with the porcelain and glass industries and deals with (1) industrial furnaces, (2) thermal calculations of furnaces, (3) gas generators, and (4) construction of various types of furnaces. M.V.C.

PATENTS

Potter's ovens. W. ROYALL. Brit. 437,901, Nov. 20, 1935 (June 9, 1934).

Stationary kilns for firing brick, block, tile, etc. A. F. BERRY. Brit. 438,377, Nov. 27, 1935 (May 18, 1934).

Geology

Automatic production of high-grade potters' flint. ANON. *Ceram. Age*, **24** [3] 75–78 (1934).—The mining, crushing, washing, drying, screening, pulverizing, and loading of quartz pebbles and sand for the production of potters' flint are described and illustrated. F.G.H.

Bentonite deposits and uses. T. POOLE MAYNARD. *Manufacturer's Rec.*, **104** [11] 27 (1935).—Bentonites are divided into two distinctive types. The so-called Wyoming type is largely confined to the Rocky Mountain States, is very waxy to the touch and in appearance, and has the peculiar property of absorbing 8 to 10 times its weight of water and swelling to a gelatinous mass. It has

a wide variety of uses in the manufacture of certain ceramic ware, in cosmetics, paints, waterproofing, emulsifying asphalt, etc. The Southern type of bentonite has much more the appearance of ordinary clay, swells very little in the presence of water, but has a bleaching property when mixed with oils after it has been boiled with sulfuric acid or hydrochloric acid. Some of the Southern bentonite deposits are described. E.J.V.

Blockite, a new selenium ore from Bolivia. R. Herzenberg and F. Ahlfeld. *Zentr. Mineral. Geol. A*, pp. 277–79 (1935).—A new ore very rich in Se, 30 km. northeast of Colquechaca, Bolivia, is described. It has the general formula RSe_2 in which R may be Ni, Cu, Ag, Hg, or Co. H.I.

British Columbia clays. Anon. *Clay Prod. News*, **8** [10] 2 (1935).—Several fine deposits of clay and sand have been located in British Columbia and some of them have been worked to a limited extent. The most important materials found include stoneware clays, fire clays, and diatomaceous earth. M.C.S.

Cleaning fire clays for use in whiteware bodies. R. A. Weinhardt. *Ceram. Age*, **24** [3] 79 (1934).—The flotation process for clay cleaning is described. A creosote-kerosene mixture is used as a flotation reagent for the removal of sulfides in a water suspension of clay. A commercial batch consists of 2000 lb. of clay, 750 gal. of water, $^1/_2$ pt. of creosote, and $^1/_2$ pt. of kerosene. The important features of the flotation operation are as follows: (1) iron compounds to be floated must not be coarser than 100-mesh; (2) rotation of the tube mill for wet grinding must be fairly slow and not more than 20 r.p.m.; (3) the slip must not be any thicker than one part clay and three parts water; and (4) air inclusion in the slip aids materially in the separation of oil-coated particles and rapid flotation. F.G.H.

Crystallization of hornblende and mica from artificial silicate melts. D. P. Grigoriev. *Zentr. Mineral. Geol. A*, pp. 117–23 (1935).—Crystalline hornblende was obtained at atmospheric pressures from melts having the approximate composition K_2O, 0.4 to $0.5Al_2O_3$, $6MgO$, $6SiO_2$, CaF_2. The hornblende was crystallized at temperatures greater than 800°C. During cooling, hornblende reacted with the melt to form phlogopite (see *Zentr. Mineral. Geol. A*, pp. 219–23 (1934)). The optical properties of the hornblende are given. H.I.

Development of French output of fluorspar. A. Chermette. *Mines, Carrières, Grandes Entreprises*, **14** [152] 7 (1935).—There were 25 mines being worked in 1930 and only 5 in 1935. Recent prospecting has led to the discovery of deposits nearer consumption centers, but leasability seems dubious. Mines actually worked are briefly described. German competition is keen and C. asks tariff protection. Illustrated. F.E.V.

Fire clay in northern Ontario. Anon. *Clay Prod. News*, **8** [10] 1 (1935).—Deposits of fire clay, kaolin, and silica sand have been located near the Mattagami River and it is planned to develop these deposits for Canadian consumption. Refractory brick, refractory cements, face brick, building tile, china clay, and silica sand are to be produced from these materials. See also "Mattagami—" *Ceram. Abs.*, **14** [5] 117 (1935). M.C.S.

Mineral formation in the system Al_2O_3–SiO_2–H_2O. W. Noll. *Neues Jahrb. Mineral. Geol.*, **70A**, 65–111 (1935).—Experiments on the synthesis of hydrated aluminum silicates were made by heating mixtures or coprecipitated gels of Al_2O_3 and SiO_2 with H_2O in bombs to temperatures as high as 500°C and pressures as great as 540 atmospheres. The products were identified by X-rays. Adsorption compounds of Al_2O_3 and SiO_2 showed no crystallization after standing for long periods at room temperatures. The Al_2O_3 in such compounds crystallized very slowly by aging in comparison with the rather rapid crystallization of Al_2O_3 in the absence of SiO_2. Kaolin was formed at temperatures less than 400°C even where the Al_2O_3:SiO_2 ratio varied widely from 1:2. The lower temperature limit of kaolin formation depends upon the duration of reaction. Kaolin can probably be formed at ordinary temperatures. In mixtures of the ratio Al_2O_3:$2SiO_2$ or in those richer in SiO_2, pyrophyllite is formed at temperatures higher than 400°C. At 500°C in compositions richer in Al_2O_3 than 1:2, two unidentified crystalline compounds were found. The presence of SiO_2 was found to hinder the formation of the more stable forms of Al_2O_3 at higher temperatures. In the presence of significant amounts of alkali and OH ions, montmorillonite is formed. Dickite and nacrite were not identified as products of any of the experiments. Conclusions from these experiments on the relation of kaolin to the weathering of feldspars and the occurrence in nature of montmorillonite, halloysite, pyrophyllite, and aluminum hydrates are given. H.I.

Mining kaolin and refractory clay in Italy. A. Lotti. *Ind. Vetro & Ceram.*, **7** [10] 427–32 (1934); abstracted in *Referat. Silikatliteratur*, No. 1182 (1935).—Italian kaolins contain a high amount of iron compounds and fine quartz particles. The mining and refining of kaolin and clays are described. M.V.C.

Raw materials for ceramic industries. L. P. *Rev. gén. Sci.*, **44** [10] 293–95 (1933).—P. gives a succinct survey of ceramic products, their uses, and the raw materials required for manufacturing them. R.W.D.

Tectites enigma. Henry de Varigny. *Rev. gén. Sci.*, **44** [4] 115–17 (1933).—Tectites are natural siliceous glasses containing small amounts of alumina, lime, ferrous oxide, and magnesia, inclosing bubbles but no crystallized minerals; their form and size vary. Their weight is generally between 10 and 90 g. (the largest specimen known weighs 464 g.). They have been discovered in various parts of the globe (Bohemia, Indo-China, Malay Peninsula, Australia, Tasmania) in quaternary and, occasionally, in ternary formations. All tectites have the same chemical composition, but their composition is far different from that of technical glasses of any epoch; their structure is exclusively vitreous. Gaseous inclusions are of the same nature as those found in meteorites. All tectites are similar although they were produced in different parts of the world. Volcanic origin and the hypothesis that tectites are dehydrated gels are confuted. Tectites are produced by meteoric phenomenon. R.W.D.

Underclays of the commercial coals of Tenn. G. I. Whitlatch. *Jour. Tenn. Acad. Sci.*, **10** [3] 205 (1935).—The average underclay of Tenn. can be classed no better than a No. 3 fire clay, and many of them can not be classed as fire clay at all. Some of the clays have commercial possibilities for the manufacture of structural brick and tile,

but as a rule the clays do not have sufficient refractoriness to be used in refractories or sufficient plasticity for high-quality pottery, sewer pipe, or similar types of products. W. suggests that these clays might find profitable adoption in the manufacture of low heat-duty refractories, grate backs, and certain types of pottery. M.C.S.

BOOK AND BULLETINS

Autobiography of the Earth. JOHN H. BRADLEY. Coward-McCann, New York, 1935. 347 pp. Price $3.00. Reviewed in *Sci. News Letter*, **28** [756] 223 (1935). —A popular account of historic geology is presented. Illustrated. H.S.

Illinois Mineral Industry in 1933. W. H. VOSKUIL AND A. P. SWEENEY. *Ill. State Geol. Surv. Rept. of Invest.*, No. 36, 69 pp. Reviewed in *Ceram. Age*, **25** [1] 27 (1935). —The production of clay, clay products, and other nonmetallic minerals is reported in detail. F.G.H.

Mineral resources of French colonies (les ressources minerales de la France d'outremer). BUREAU D'ÉTUDES GÉOLOGIQUES ET MINIERES COLONIALES. Reviewed in *Rev. géol.*, **15** [7–8] 408 (1935).—Parts I and II deal with coal and iron. Part III contains a series of studies intended to give complete documentation on geology, mining, production, marketing, and mining policy of nonferrous ores and other minerals (mica, asbestos, salt, potash, etc.) in the French colonies. Part IV is devoted exclusively to calcium phosphate, the largest part of which is supplied by French North Africa. The work is the result of a comprehensive investigation undertaken with government support. F.E.V.

Chemistry and Physics

Absorbed sodium in soils as affected by the soil-water ratio. FRANK M. EATON AND V. P. SOKOLOFF. *Soil Sci.*, **40** [3] 237–47 (1935). G.R.S.

Absorption and index of refraction of aquamarine and some yellow and green beryls. H. KLANG. *Neues Jahrb. Mineral. Geol.*, **69A**, 93–115 (1935).—Light absorption, index of refraction, and density were determined on a series of blue, yellow, and green beryls. There is no exact relation between density and index of refraction. The blue, yellow, and green beryls show continuous absorption in the visible spectrum. The form of the absorption curves permits separation of beryls into four types. H.I.

Color reactions in the microchemical determination of minerals. J. ADAM WATSON. *Mineral. Mag.*, **24**, 21–34 (1935).—A description of the method of color or "spot" tests in the qualitative analysis of minerals is given, with the reagents used and the color reactions for the different elements. H.I.

Coloration of minerals by manganese, chromium, and iron. ERNST KOLBE. *Neues Jahrb. Mineral. Geol.*, **69A**, 183–253 (1935).—The absorption curves in the visible spectrum were measured of a number of compounds of Mn, Cr, and Fe, which contained these elements in different valence stages. These were compared with the absorption curves of natural minerals to determine the nature of the coloring matter. Mn was the coloring agent in red tourmaline and contributed to the color in almandine. Chromium may be the cause of violet and blue color as well as red and green, depending on the valence. Deviation from pure red color in natural corundum does not depend upon Cr concentration but on the presence of other coloring elements. H.I.

Determination of iron, chlorine, and lead. J. E. MILLS *et al.* *Jour. Australian Chem. Inst.*, **2** [10] 298–304 (1935).—A discussion is given by the analytical group of recent developments in Fe, Cl, and Pb determination in organic and inorganic materials. H.H.S.

Development of chemical symbols. I. W. D. HACKH. *Sci. Monthly*, **40** [3] 199–217 (1935).—The evolution of the chemical symbols illustrates the attempts of the human mind to represent its concept of facts and fancy in a concise way. Beginning with the ideogrammatic hieroglyphics, the development of chemical symbols is traced through the allegorical symbolism of the alchemists into the simple notation of today. Newer developments in physical and organic chemistry make it desirable to use graphs and diagrams of the molecule. Structure symbols provide a simple means of showing qualitatively (as diagram) or quantitatively (as graph) the different type of bonds between the atoms, polarity and polarization, orientation, colloidal structure, atomic distances, and electronic constellations, besides the more familiar structural relationships, such as isomerism and the possible future compounds of isotropic carbon, hydrogen, and oxygen. H.E.S.

Dielectric constants and dipole moments. G. A. ELLIOTT. *Jour. Australian Chem. Inst.*, **2** [9] 254–66; [10] 281–97 (1935).—The work of Debye and others is described, and it is shown how dipole moments can be used to elucidate chemical constitution. H.H.S.

Direct determination of barium salts. A. V. VINOGRADOV. *Ann. chim. anal. chim. appl.*, **17** [10] 285–86 (1935).—Using potassium chromate as reagent and rosolic acid as indicator, the method permits the direct determination of sulfates and particularly that of sulfur present in pyrites or slags. By substituting rosolic acid (6 drops of a 0.1% solution to every 25 to 30 cc. of the liquid being analyzed) for other indicators, a neat color develops in the test, yellow (p_H 6.9) or red (p_H 8). Results given by the method are sufficiently accurate for routine analysis. R.W.D.

Electrical measurement of clay drying. T. A. GOSKAR. *Claycraft*, **9** [1] 25 (1935).—A method for measuring the safe rate for drying clay products was recently developed. The clay to be tested is made into test pieces 6 by 1 by $^1/_2$ in., and these are placed in the circuit of a 230 v. a.-c. system, the contacts being made on the two opposite 6- by 1-in. faces. The resistance offered by the clay increases with the decreasing moisture content, and the drying time decreases with decreasing moisture content. These relationships are definitely determined for each particular clay by this test. M.C.S.

Emission spectrum of the selenium oxide SeO. L. BLOCH, E. BLOCH, AND CHOONG SHIN-PIAW. *Compt. rend.*, **201** [19] 824–25 (1935).—The most convenient method of

exciting the spectrum of this vapor is by placing the latter in a bottle in an electric oscillator producing undamped waves; the spectrum extends from 3800 to 2880Å. The fundamental vibration frequencies of the molecule SeO in the normal and in the excited state are 908.9 and 553.4 cm.$^{-1}$, respectively. The dissociation energy of the normal molecule was determined to 5.31 v. M.H.

Equilibrium relationships of Fe_3O_4, Fe_2O_3, and oxygen. J. W. Greig, E. Posnjak, H. E. Merwin, and R. B. Sosman. *Amer. Jour. Sci.*, **30**, 239–316 (1935).—The equilibrium relationships of Fe_3O_4, Fe_2O_3, and oxygen have been studied over the range 1075 to 1600°C. At 1075°C magnetite (solid solution) containing 92 ±1% Fe_3O_4 and 8 ±1% Fe_2O_3 can coexist in equilibrium with hematite (containing less than 0.5% Fe_3O_4) and O_2 at a low pressure (exact value unknown). As the temperature is raised the magnetite in equilibrium with hematite and O_2 becomes considerably richer in oxygen while the hematite (solid solution) becomes slightly lower in oxygen. At 1452° ±5° magnetite containing 70 (+2 or −1)% Fe_3O_4 and 30 (−2 or +1)% Fe_2O_3 is in equilibrium with hematite containing less than 1% Fe_3O_4 and with O_2 at 1 atmosphere. The extent of solid solution has not been traced above or below this range. Fe_3O_4 melts to a liquid of the same composition at 1591° ±5° under a small but undetermined pressure of O_2. Magnetites of higher oxygen content melt at a slightly lower temperature, the liquid with which they are in equilibrium being richer in oxygen than the crystals. The melting point of hematite, although not determined exactly, appears to be below that of platinum. A eutectic is formed between magnetite (solid solution) and hematite, but the exact equilibrium data have not been determined. Comparison of platinum and rhodium as crucible materials revealed that, in platinum, iron is taken up to leave excess oxygen, thus increasing the oxygen content of the oxide; on the other hand, in rhodium, the oxygen content is often apparently decreased through rhodium pick-up by the charge. Actually the effect of rhodium depends on its state of oxidation, which is uncertain. Observations on the refractive index and color of the oxides are reported. A descriptive section includes notes on oxidation, dissociation, sintering and recrystallization, and unmixing, and on the microstructures developed by these processes. An error in the Mitscherlich method of analyses for ferrous iron is pointed out. The e.m.f. of a Pt-PtRh thermocouple in a stream of O_2 is found to change rapidly at high temperatures. J.B.A.

Immiscible silicate melts which approximate natural rocks in their composition. D. P. Grigoriev. *Zentr. Mineral. Geol. A*, pp. 242–51 (1935).—Melts of complex silicates containing CaO, MgO, SiO_2, Al_2O_3, and K_2O tend to form two immiscible liquids if they contain a sufficient amount of volatile constituents such as fluorine. Melts of the same composition without volatile constituents are completely soluble in the liquid state. H.I.

Increasing plasticity of kaolins and clays. R. Angenitzkaya and I. Romankevich. *Keram. i Steklo*, 11 [7] 27–32 (1935).—Various theories dealing with plasticity are discussed and a series of studies made by the authors is described. It was found that the increase of the absorption capacity, through "exchange" reactions with sodium under the effect of NaOH, is very limited, and the plasticity of clay material is therefore increased slightly. The increase of the plastic properties of clay material by means of the exchange of cations can be obtained by a simultaneous increase of the absorption capacity by introducing admixtures with a greater absorption and high adsorbing properties. M.V.C.

Index for measuring the surface of a mineral powder wanted. A. J. Weinig. *Eng. Mining Jour.*, **136** [7] 336–42 (1935).—W. shows that it is impossible to derive mathematically the surface area of powders from data secured in screen tests because of variations in the shape of the particles. For the same reason, grain counts or sedimentation results do not give sufficient data for accurate computation of this surface area. He derives a formula for the surface index which allows for this variation in size by relating it to weight: $S = \frac{2 + R}{3}$, where S is the surface index (a coefficient which, multiplied by $6x^3$, the area of a cube of side x, gives the mean surface of a particle other than a cube passing through an aperture of side x) and R is the ratio of the theoretical weight of a grain considered as a cube to the actual weight of a grain found by averaging the weight of a hundred grains. In applying the formula, grains on the screens are counted under the microscope and weighed to determine the average weights of grains. Several charts for evaluating the surfaces of ore grinds and diagrams of different grain shapes of unit mesh size are given. J.L.G.

Industrial spectrum analysis. C. S. Hitchen and C. J. D. Gair. *Chem. Age*, **33** [July 20] 51–52; [July 27] 75–76; [Aug. 3] 99–101 (1935). H.H.S.

Linear thermal expansion of sodium tungstate between 20° and 600°. J. B. Austin and R. H. H. Pierce, Jr. *Jour. Chem. Physics*, **3** [11] 683–86 (1935).—The linear thermal expansion of anhydrous sodium tungstate was determined between 20° and 600°C by means of an interferometer, with the results given by a series of equations. At atmospheric pressure the salt is trimorphous. Modification III is stable on heating up to 585° at which temperature it transforms to II with an increase in volume of 17.4%. Form II is stable over a very short temperature interval whose exact extent could not be determined, and then transforms to Na_2WO_4 I with a decrease in volume of 0.12%. G.R.S.

Mathematical relations between total exchange capacity and absorption of ammonium and potassium by soils. F. J. Fudge. *Soil Sci.*, **40** [4] 269–84 (1935).—Five mathematical equations expressing the relations between total exchange capacity and the absorption by soils of ammonium and potassium from solutions of ammonium sulfate and potassium sulfate were studied to determine which equation gave values in best agreement with experimental results. Quantities of base absorbed varied approximately with the total exchange capacity. Marked differences were evident in the quantity of base absorbed by soils of similar exchange capacity from identical solutions. These were probably due to the relative importance of capillary absorption and to differences in the compounds making up the exchange complex. The equation $y = KC^1/p$ gave values which are in best accord with the values determined experimentally. The values of K, when divided by the total exchange capacity, T, gave a quotient which was

fairly similar for all soils. It indicated significant differences in the absorptive capacity of some soils per unit of exchange complex. The values of p were practically constant for all soils. The equations best fitting the general data were $y = 0.0648\ TC^{71}$ for ammonium and $Y = 0.0851TC^{71}$ for potassium. G.R.S.

Metallographic grinding and polishing. E. HAARDT. *Schleif & Poliertech.*, **12** [4] 69 (1935).—The usual process for cutting, grinding, and polishing a metallographic specimen is described. Granulometry of successive abrasives is given. Soft metals and soft materials are more difficult to deal with. Particulars are given for special cases. F.E.V.

Microdetection of chromium. W. B. S. BISHOP AND F. P. DWYER. *Jour. Australian Chem. Inst.*, **2** [10] 278–80 (1935).—The blue color produced with H_2O_2 is extracted with amyl acetate. Ti produces a yellow color, not extractible by the solvent, but V, Mo, and W interfere. H.H.S.

Optical diagram of the magnesium-iron mica (phlogopite). D. P. GRIGORIEV. *Zentr. Mineral. Geol. A*, pp. 142–50 (1935).—Variations of optical properties with composition are given. H.I.

Organic soil carbon by reduction of chromic acid. L. E. ALLISON. *Soil Sci.*, **40** [4] 311–20 (1935).—A critical examination was made of Schollenberger's method for determining soil organic carbon by the reduction of chromic acid. Compared to furnace combustion, this method offers the following advantages: (1) it is approximately 50% more rapid; (2) it is unaffected by the presence of carbonates in the sample; and (3) it does not determine inert carbon. The conditions of time and temperature of oxidation by chromic acid reduction give uniformly incomplete oxidation of soil organic carbon. A conversion factor of 1.15 is required to bring carbon values by this method into agreement with furnace combustion data. G.R.S.

Oxides of potassium. C. A. KRAUS AND E. F. PARMENTER. *Jour. Amer. Chem. Soc.*, **56** [11] 2384–88 (1934). —Improvements in the preparation of K_2O_2 and K_2O_4 are briefly described. The existence of the following compounds was established: K_2O_2, $K_2O_2{\cdot}H_2O$, $K_2O_2{\cdot}2H_2O$, and $K_2O_2{\cdot}H_2O$. The properties and reactions of these compounds are described. F.G.H.

Photomicrographs of optic axes of opaque minerals in the infra-red. DAVID MALMQVIST. *Zentr. Mineral. Geol. A*, pp. 209–13 (1935).—Photographs of the optic axes of molybdenite on cleavage plates between 7 and 145 microns thick are reproduced. Many other sulfide minerals as well as oxides which are relatively opaque to visible light are probably transparent to infra-red. H.I.

Precision determination of lattice constants. ERIC R. JETTE AND FRANK FOOTE. *Jour. Chem. Physics*, **3** [10] 605–16 (1935).—The theoretical and experimental conditions which must be satisfied to determine lattice constants with a precision of a few parts per hundred thousand are discussed with particular application to the symmetrical focusing type of camera. Cohen's method of calculation of lattice constants for the elimination of "drift" and experimental errors is applied. Methods are developed for the evaluation of standard errors and fiduciary limits of results from a single film and from a set of films. The usefulness of X-ray targets made of alloys rather than pure elements for the purpose of securing a larger number and better distribution of lines is indicated. The influence and the number and Miller indices of diffraction lines on the values of lattice constants in noncubic systems is shown. The importance of the methods of sample preparation for precision work is emphasized. Precision measurements on Al, Ni, Ag, Au, Si, Fe, Mo, W, Mg, Zn, Cd, Sb, Bi, and Sn are reported for materials of a high degree of purity. The fiduciary limits of these lattice constants vary between 2 and 7 parts per hundred thousand and are so chosen that the probability of the correct value lying between the stated limits is 19 out of 20. G.R.S.

Properties of a thin layer of clay-water solution interposed between solid surfaces. HIKOTARO TAKO. *Bull. Inst. Phys. Chem. Research*, **14**, 909–19 (1935); English abstract in *Sci. Papers, Inst. Phys. Chem. Research*, **28**, 59 (Oct., 1935).—The coefficient of friction of a rubber plate sliding on a concrete block wet with a clay-water suspension becomes less as the concentration (c) of clay increases. The motion of the plate on the block has been studied photographically. There is an optimum velocity (V_o) for which the resisting force acting on the plate is a minimum. The product of V_o and N, the viscosity of the suspension, is roughly proportional to $\sqrt{c}$. Addition of electrolyte does not alter V_oN appreciably. J.B.A.

Reaction of carbon monoxide on molybdenum oxides. H. M. SPENCER AND J. L. JUSTICE. *Jour. Amer. Chem. Soc.*, **56** [11] 2301–2306 (1934).—At 400°C the reduction of molybdenum trioxide by carbon monoxide is very slow. The end-product of the reduction is apparently molybdenum dioxide, but no determinations established this conclusion definitely. At 560°C molybdenum is reduced by carbon monoxide to molybdenum carbide, and the carbide catalyzes the decomposition of carbon monoxide. At 810°C molybdenum dioxide is reduced to molybdenum carbide (Mo_2C). The overall reaction is reversible and may be represented by the following equation: $2MoO_2 + 6CO = Mo_2C + 5CO_2$. F.G.H.

Rotational force of quartz for rays perpendicular to the optical axis and its dispersion between 2537 and 5780Å. GEO. BRUHAT AND LOUIS WEIL. *Compt. rend.*, **201** [20] 887–89 (1935).—The study showed that in the whole interval examined the rotational dispersion of quartz is the same for rays both perpendicular and parallel to the axis. M.H.

Separation of tungsten from titanium, niobium, zirconium, and tantalum. A. R. POWELL, W. R. SCHOELLER, AND C. JAHN. *Analyst*, **60**, 506–14 (Aug., 1935).—This is paper No. 29 of analytical investigations into the earth-acid minerals. The only procedure found to separate W from Ti and Nb(Cb) consists in fusing the mixed oxides with K_2CO_3 and treating the aqueous extract with ammoniacal Mg salt solution. The earths are precipitated, while alkali tungstate remains in solution. H.H.S.

Silica determination by the weight method. N. A. TANANAEV AND M. K. BUITCHKOV. *Zavodskaya Lab.*, **4** [6] 648–50 (1935).—A quick determination of silica by decomposing the alkaline fusion by concentrated nitric acid with a subsequent addition of gelatine of a concentration 0.1 g. in 100 ml. of hot water to accelerate the coagulation of turbid matter is suggested. P.B. & E.S.

Sorel cement for the production of microscopic thin sections of mineral soils. HARALD BJÖRLYKKE. *Chem. Erde*, **9**, 50–51 (1934).—Fine-grained magnesium oxide powder is added to a concentrated solution of $MgCl_2$ to form a thick paste, and the grains of the soil to be sectioned are mixed into the paste. The mixture is allowed to set on a glass plate and the thin section is made in the usual way. The grains of the mineral powder are held more tenaciously than in Canada balsam and the usual cementing agents. H.I.

Thermal decomposition of talc. R. H. EWELL, E. N. BUNTING, AND R. F. GELLER. *Jour. Research Nat. Bur. Stand.*, **15** [5] 551–56 (1935); R.P. 848. Price 5¢.—A sample of a nearly pure talc was investigated both unheated and after heating at 18 temperatures from 340 to 1435°C. The studies included the determination of heat effects, weight losses, and changes in true specific gravity occurring on heating talc. X-ray changes and microscopical examinations were made of the heated samples. Water in excess of 1 molecule was mostly driven off between 380° and 500°C. This water loss was accompanied by a small endothermic heat effect, but not by any change in crystal structure or optical properties. The molecule of combined water was driven off between 800° and 840°C. This water loss was accompanied by a large endothermic heat effect and an increase in true specific gravity from 2.83 to 2.91 and by breakdown of the talc into enstatite and amorphous silica. Inversion of the enstatite to clinoenstatite took place gradually, both phases being observed in material heated at 1200°C and only clinoenstatite in material at 1300°C. The material heated at 1300°C also showed conversion of the amorphous silica to cristobalite. Thus the final products of the thermal decomposition of talc are clinoenstatite and cristobalite. There was a further gradual increase in the true specific gravity from 2.91 to 3.01 on heating from 840° up to the highest temperature, 1435°C. The data support the hypothesis of Foshag and Wherry that water in talc in excess of 1 molecule is not constitutional and may be held electrostatically between basal cleavage planes. R.A.H.

Standardization of permanganate solutions with sodium oxalate. ROBERT M. FOWLER AND HARRY A. BRIGHT. *Jour. Research Nat. Bur. Stand.*, **15** [5] 493–501 (1935); R.P. 843. Price 5¢.—McBride's method for the standardization of permanganate solutions with sodium oxalate yields titers that are too high. A procedure is recommended for the exact standardization of permanganate with sodium oxalate. R.A.H.

Vitreous state. A. D. *Rev. gén. Sci.*, **46** [6] 167–69 (1935).—Glasses and vitreous materials form a class of varied substances which cannot be characterized except by general and common properties. The main property involved in previous ideas on vitreous state is that glasses are supercooled bodies; this is in agreement with the slow secular crystallization of glass. Tammann inferred that most substances would likely be susceptible of producing glasses were we able to cool them down from their fusing point quickly enough. Other authors admit that molten glass contains "crystallites" of the same nature as true crystals scattered at random and responsible for the high viscosity of the metal, primary cause of possible prolonged surfusion. X-ray investigations have revealed the existence of definite crystal aggregates. Zachariasen indicated the fundamental part assigned to oxygen in the production of these aggregates (polyhedrons); provided that these are not regularly distributed, the medium which includes them remains isotropic. When melting calcium metaborate, $Ca(BO_2)_2$, the ionic link between Ca^{++} and BO_2^- is disrupted; radical BO_2 coördinates atoms of oxygen and produces aggregates $(BO_2)_n$. All metalloids such as silicium, arsenic, etc., which coördinate atoms of oxygen, are proper to form glasses. Hägg applied similar considerations to different varieties of glasses. R.W.D.

BOOKS

Experimental Physical Chemistry. FARRINGTON DANIELS, J. HOWARD MATHEWS, AND JOHN WARREN WILLIAMS. (International Chemical Series) 2d ed. xix + 499 pp. McGraw-Hill Book Co., Inc., New York, 1934. Briefly reviewed in *Nature*, **136** [3439] 495 (1935).—A comprehensive guide for student and research worker. J.L.G.

Spectroscopy. KARL WILH. MEISSNER. (Sammlung Goschen, Vol. 1091) 180 pp. Walter de Gruyter and Co., Berlin and Leipzig, 1935. Price 1.62 gold marks. Briefly reviewed in *Nature*, **136** [3438] 457 (1935).—An elementary account in German of spectroscopic principles and methods. J.L.G.

Theory of Atomic Spectra. E. U. CONDON AND G. H. SHORTLEY. Cambridge University Press, 1935. 441 pp. Price $11.00. Reviewed in *Sci. News Letter*, **28** [758] 255 (1935).—This comprehensive book collects and interprets the present state of this field. H.S.

X-Rays in Theory and Experiment. ARTHUR H. COMPTON AND SAMUEL K. ALLISON. 2d ed. of "X-Rays and Electrons" by Arthur H. Compton. xiv + 828 pp. D. Van Nostrand Co., Inc., New York, 1935. Reviewed in *Nature*, **136** [3443] 661–62 (1935).—The second edition contains over twice as much data and interpretation as the first. The history of X-rays, the theory of their production, and the theory of their scattering (by electrons, by atoms, by liquids, and by crystals) are discussed. Then follows a consideration of the fluorescence, the absorption, and the spectroscopy of X-rays. Chapter 3, on scattering, serves as a fine introduction to the new quantum theory. Wave mechanics is used in solving some of the problems which arise. The book is recommended as a reference work for physicists and crystallographers. J.L.G.

PATENTS

Manufacture of zinc oxide. E. H. BUNCE, C. J. LENTZ, AND G. T. MAHLER (New Jersey Zinc Co.). U. S. 2,021,284, Nov. 19, 1935 (March 24, 1930).

Process for obtaining pure aluminium-alkali double fluorides. F. W. HILSCHER AND VEIT SCHWEMMER (Saline Ludwigshalle). U. S. 2,021,601, Nov. 19, 1935 (June 15, 1931).

Production of lithium compounds. H. P. CORSON AND ROBERT PFANSTIEL (Grasselli Chemical Co.). U. S. 2,021,988, Nov. 26, 1935 (Jan. 20, 1934).

Production of pure lithium compounds from impure solutions. H. S. COLTON (Grasselli Chemical Co.). U. S. 2,021,986, Nov. 26, 1935 (Jan. 20, 1934).

Recovering lithium compounds. J. H. COLEMAN

AND N. E. JAFFA (Warner Chemical Co.). U. S. 2,024,026, Dec. 10, 1935 (Nov. 17, 1933).

Recovery of lithium values from lithium-bearing ores. R. J. KEPFER AND ROBERT PFANSTIEL (Grasselli Chemical Co.). U. S. 2,022,003, Nov. 26, 1935 (Jan. 20, 1934).

Recovery of values from lithium-bearing ores. H. S. COLTON (Grasselli Chemical Co.). U. S. 2,021,987, Nov. 26, 1935 (Jan. 20, 1934).

General

Brussels Exhibition, 1935. ANON. *Studio*, **110** [509] 55–75, 88–95 (1935).—Among the 47 illustrations are photographs of the glass and ceramic exhibits of Sweden and Denmark and several arrangements of "art of the table." H.H.S.

China's National Bureau of Industrial Research. YU-TSUAN KU. *Bull. Amer. Ceram. Soc.*, **14** [12] 406 (1935).

Five thousand years of engineering. R. H. FERNALD. *Sci. Monthly*, **40** [3] 272–75 (1935).—A brief review of five thousand years of engineering reveals era after era of progressive development. Our industrial and economic supremacy today is due to (1) the universal distribution of energy in the form of power, (2) development of almost human machines, and (3) science of the management of men. F. visions for the future unprecedented prosperity which will call for superior inventive genius, outstanding engineering capacity, and aggressive directing foresight. H.E.S.

Industry's power. PHILIP W. SWAIN *et al.* *Factory Management & Maintenance*, **93** [10] *S*109–32 (1935).—Nine articles on industrial power compose this symposium. Bibliography of 35 titles. J.L.G.

Lighting does a production job. BERNARD SHEREFF. *Factory Management & Maintenance*, **93** [10] 436–38 (1935).—S. describes the way in which better factory lighting reduced losses from defective work in one plant. Illustrated. J.L.G.

Motion economy. ALLEN H. MOGENSEN. *Factory Management & Maintenance*, **93** [11] *S*133–48 (1935).—M. explains the way in which a motion economy program should be set up. Illustrated. J.L.G.

Planning in industry. O. W. ROSKILL. *Jour. Soc. Glass Tech.*, **19** [75] 157–83*P* (1935).—The name "planning" was given to attempts to improve the position with respect to (*a*) lack of background thinking in executive and political circles and (*b*) lack of coördination between specialized and technical activities. The subject was considered under (1) planning and initiative, (2) division of the field of industry, (3) terms of trade, (4) coöperation in industry, trade associations, (5) industrial self-government, and (6) delegation of power by Parliament. In the discussion, W. Prescott discussed the subject of "Influence of Personality" and P. G. Donald, the subject of "Enabling Bills." These were followed by a general discussion. A.A.

Variation in the quality of products. Some technical and commercial considerations. B. P. DUDDING. *Jour. Soc. Glass Tech.*, **19** [75] 141–56*P* (1935).—The treatment of the subject is followed by a general discussion. A.A.

BOOKS

Ceramic Trade Directory, 1935. Ceramic Publishing Co., Inc., Newark, N. J., 1935. 198 pp. Price $5.00. Reviewed in *Ceram. Age*, **26** [4] 159 (1935).—All divisions of the whiteware industry in the U.S. and Canada are listed in alphabetical form, including artware, chinaware, earthenware, electrical porcelain, floor and wall tile, miscellaneous whiteware, sanitary ware, stoneware, and terra cotta. The data on different companies include plant location, character of ware produced, company personnel, and other plant information. A list of ceramic colleges and schools and a compilation of technical and trade associations are also included. F.G.H.

German-English Dictionary of Metallurgical Terms (Deutsch-Englisches Fachwoertenbuch der Metallurgie). H. FREEMAN. Otto Spamer, G.m.b.H., Leipzig. 327 pp. Reviewed in *Foundry*, **62** [8] 62 (1934). **Part 2. English-German.** 347 pp. Price 25 Rm. Reviewed in *Mech. Eng.*, **56** [8] 502 (1934). F.G.H.

Mechanization in Industry. HARRY JEROME. xxxi + 484 pp. National Bureau of Economic Research, Inc., New York, 1935. *Pub. Nat. Bur. Econ. Research, Inc.*, No. 27; reviewed in *Nature*, **136** [3443] 659–60 (1935).—The relation of mechanization in industry to economic life as a whole is the subject of J.'s work. He believes that while continued increase in mechanization will occur, there are strong factors which will prevent uncontrollably rapid increase. The ill effects of too rapid mechanization, such as technological unemployment, are considered. J.L.G.

PATENT

Process for manufacturing fireclay materials with embedded bars of iron wire. O. EVANS (Vereinigte Stahlwerke A.-G.). Brit. 438,794, Dec. 4, 1935 (May 16, 1934).

THE AMERICAN CERAMIC SOCIETY

Incorporated in 1899

TO PROMOTE CERAMIC ARTS, SCIENCE, AND TECHNOLOGY
IS A CONTINUATION EDUCATIONAL "COÖPERATIVE"
IT PUBLISHES REPORTS OF ORIGINAL RESEARCHES
AND ABSTRACTS WORLD-WIDE
CERAMIC LITERATURE

IN 1935

1346 Paid Personal Dues of $12.50
187 Paid Minimum Corporation Dues of $25.00
488 Firms and Libraries Subscribed

YOUR PARTICIPATION IN THIS "COÖPERATIVE" IS SOLICITED

THE AMERICAN CERAMIC SOCIETY
2525 NORTH HIGH STREET
COLUMBUS, OHIO

Vol. 19, No. 2, Journal, pp. 29-62 JOURNAL OF THE AMERICAN CERAMIC SOCIETY, FEBRUARY, 1936 Vol. 15, No. 2, Ceramic Abstracts, pp. 31-78

1936 ANNUAL MEETING
American Ceramic Society
COLUMBUS, OHIO
March 29 to April 4

SCHEDULE OF MEETING PLACES

	Saturday Mar. 28	Sunday Mar. 29		Monday Mar. 30		Tuesday Mar. 31		Wednesday Apr. 1		Thursday Apr. 2	Friday Apr. 3	Saturday Apr. 4
	All Day	All Day	Night	All Day	Night	All Day	Night	All Day	Night	All Day		
Trustees	Wallick Suite		President's Reception—Concert—Deshler Ball—8:00	Wallick Suite	General Meetings—Deshler Ball	Wallick Suite	Edward Orton, Jr., Lecture—9:00—Deshler Ball	Wallick Suite	Dance—Floor Show—Neil Ball	Wallick Suite		
Trustees and Committees		Deshler A. B. C.										
Art Division					Supper—Entertainment—7:30—Deshler Ball	Neil Blue		Neil Blue		Extra Division Sessions—Tour of Columbus Claycraft—Enamel—and Glass Factories Ohio State University—Battelle—Orton Lab.	Zanesville Roseville Crooksville	
Enamel Division						Deshler A. B. C.		Deshler A. B. C.			Newark	
Glass Division						Neil Ball		Neil Ball			Newark Lancaster	
Materials and Equipment												
Refractories						Deshler Ball		Deshler Ball				
Structural Clay						Neil Red		Neil Red			Claycraft New Lexington New Straitsville	
Terra Cotta						Neil Garden		Neil Garden				
White Wares						Neil Jr. Ball		Neil Jr. Ball			Zanesville Crooksville	
Registration		← Deshler Assembly Room →										
						← Neil Mezzanine →						
Publicity and Editorial		← Room 21 Deshler →										
						← Neil Mezzanine →						

EXECUTIVE COMMITTEE

George A. Bole, Manager, Edward Orton, Jr., Ceramic Foundation, 1445 Summit St., Columbus, Ohio.
Clyde E. Williams, Battelle Memorial Institute, Columbus, Ohio.
C. Forrest Tefft, P. O. Box 866, Columbus, Ohio.
Earl Crooks, Crooksville China Co., Crooksville, Ohio.
Frank Ransbottom, Robinson-Ransbottom Pottery Co., Roseville, Ohio.
Arthur S. Watts, Lord Hall, Ohio State Univ., Columbus, Ohio.

COMMITTEE CHAIRMEN

Meeting Service: John D. Sullivan, Battelle Memorial Institute.
Entertainment: Ross C. Purdy, 2525 N. High St.
Ladies' Entertainment: Mrs. Ellsworth P. Ogden, 1957 Chelsea Road.
Plant Trips: J. L. Carruthers, Lord Hall, Ohio State Univ.
Publicity: Clyde E. Williams, Battelle Memorial Institute.
Exhibits: Arthur S. Watts, Lord Hall, Ohio State Univ.
Finances: C. Forrest Tefft, P. O. Box 866.